EnviroGroup Limited

The environmental solutions company

December 29, 1999

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EPA, REGION VIII
SUPERFUND BRANCH

David Mellard, Ph.D.
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry
Mailstop E-32
1600 Clifton Road
Atlanta, GA 30333

RE: Information requested by ATSDR
VB-I70 Site

Dear David:

As you requested, enclosed is information from the Tourtelot (USGS) and Skyline Labs studies.

The Tourtelot package includes the cover letter under which Harry Tourtelot of the USGS provided soil sampling data from the Front Range Urban Corridor Study to Macon Cowles, the attorney representing the Escamilla Class in Globeville. I do not have the original computer print-outs, but attached is a spreadsheet that presents data from this study for samples collected in the Denver area, prepared by EnviroGroup in 1992. The data consist of random samples collected from 4km square "sample areas" or blocks. Four samples were collected from each block . The location of each block is shown on the attached map (Tourtelot deposition exhibit 139). I've marked the blocks for which we have data in red. The blocks that we consider to be in an "urban setting" are highlighted in yellow. The calculation of the geometric mean and standard deviation for this urban subset is shown on the attached table. Note that sample area 101 is in the general vicinity of the VB-I70 study area. None of the samples were collected from the vicinities of the Globe or Omaha Grant smelters. Sample area 100 is immediately west of the former Argo smelter site.

The Skyline Labs data package consists of the Skyline Labs, Inc. laboratory analyses report of February 24, 1986, and a contour map of the data prepared by EnviroGroup. The x y coordinates of the samples listed on the lab report are the same as shown on the map (one unit equals one mile). I have highlighted the 500 ppm to 750 ppm contour interval for convenience. Skyline Labs apparently conducted the study of its own volition. To the best of my knowledge, it was never published, but Skyline agreed to provide the data to EnviroGroup around 1992 when the Escamilla lawsuit raised questions about urban background levels.

7208 South Tucson Way, Suite 125 • Englewood, Colorado 80112 • 303 790-1340 • Fax 303 790-1347

Also attached are excerpts from Fell 1979, establishing the dates when the Argo and Grant smelters began and ceased operations, a paper by Klodt (1952) on the Argo smelter process and history, an excerpt from Fossett (1879) on the early Argo process, and a modern day airphoto showing the locations of the various smelter sites.

I hope this information is helpful. Please do not hesitate to call me if you have any questions.

Sincerely,
EnviroGroup Limited

David J. Folkes, P.E.
Principal

Enc.

Cc: Bonnie Lavelle, USEPA (w/enc.)
Bob Litle, Asarco (w/o enc.)
Linda Larson, Esq. (w/o enc.)

Ores to Metals

The Rocky Mountain Smelting Industry

James E. Fell, Jr.

James E. Fell, Jr.

University of Nebraska Press • Lincoln and London

The publication of this book was assisted by a grant from The Andrew W. Mellon Foundation.

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For My Mother and Fatl

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Chapter 6

Smokestacks on the Plains

DURING THE SIXTIES AND SEVENTIES MANY HAD RECOGNIZED that the cities and towns on the Great Plains held excellent potential as ore reduction centers. Some noted that labor, fuel, and material costs were far less here than in the isolated mining camps of the high country. Others saw that an efficient system of railroads could unite a wide variety of minerals for treatment in smelting furnaces. Yet the absence of rail service had compelled the early entrepreneurs to locate their plants in the mountain fastness near the sources of fuel and ore. During the seventies, however, railroad construction began to link the major cities, towns, and mining camps and opened new opportunities to the most perceptive smeltermen.

Denver was the nexus of railroad building in Colorado. The construction of the Kansas Pacific and the Chicago, Burlington, and Quincy lines gave the city direct service to the East, and the Union Pacific road, through its subsidiaries, the Colorado Central and Denver Pacific, provided an east-west link through Cheyenne. Within Colorado the Denver & Rio Grande Railway built south from Denver to Colorado Springs, Pueblo, and Trinidad, then west from Pueblo to Leadville and Durango. West of Denver the Colorado Central Company laid narrow-gauge rails up Clear Creek Canyon to Central City, Idaho Springs, and Georgetown. And the Denver South Park and Pacific enterprise extended its tracks to Fairplay, Alma, and Leadville.[1]

As these roads made Denver a highly prospective site for the reduction industry, Nathaniel P. Hill and his colleagues in the Boston and Colorado Smelting Company had begun to think about consolidating their operations on the Great Plains. A decade of rapid growth had carried the Black Hawk plant to the limits of expansion in the narrow, high-walled canyon carved by North Clear Creek. Since 1876 production had risen slowly, partly because of the physical constraints imposed by the setting. Increases in the cost of fuel had eroded profit margins, and high freight tariffs had thwarted Hill's plans to switch from wood to coal. But moving the plant to a more centralized location offered Hill the prospect of further growth because the enterprise could draw on the production of a wider range of mining camps. Finally, the suit filed in circuit court at the behest of Carl Schurz forced the company's hand. Hill and his associates decided to consolidate their smelting and refining operations at the edge of the eastern slope. And it was to Denver, with its excellent railroad system and lower costs, that the enterprise looked for a new plant site.[2]

Relocation was no simple matter, however, because a peculiar track arrangement connected Denver to the mining camps on the forks of Clear Creek. Freight originating in Denver had to travel over the broad-gauge track of the Colorado Central Railroad as far as Golden. There yard crews transferred the cargo to narrow-gauge rolling stock for the journey into the mountains. The opposite procedure applied to shipments coming down from the mining towns. People in Denver and in the high country had long urged the Central to lay a third rail permitting direct, less-expensive transport between Denver and Golden, but William A. H. Loveland, president of the line, refused. He used various pretexts to justify his position, but the real reason for his opposition was that he feared his warehouses and retail stores in Golden might suffer if Denver instead of Golden became the principal transfer point.[3]

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Hill thought the construction of a third rail was vital. If he erected a smelter in Denver, the bulk of his mineral would roll down Clear Creek Canyon on narrow-gauge ore cars as far as Golden, where it would have to be transferred to broad-gauge rolling stock for shipment to the works. Hill considered this expensive, time-consuming, and unnecessary. It defeated the purpose of relocation. In the summer of 1877 he had tried to persuade Loveland to lay a third rail and reduce the expense of shipping coal to Black Hawk, but Loveland had refused, realizing that the smelting company was dependent upon his line. Once Hill and his associates decided to shift their location, Hill reopened his talks with Loveland, who remained adamantly opposed to laying a third rail.[4]

Hill then shifted tactics. He let it be known that he intended to build his own railroad between Denver and the towns above Clear Creek. In retrospect it seems that this scheme was little more than a clever ploy to force the Central to come to terms, but it had to be taken seriously at the time. One commentator wrote that Loveland would have to reach an agreement with Hill because the railroad bore a heavy debt and would fail to meet its obligations if it had to compete with another carrier.[5]

Regardless, Hill wasted little time in putting pressure on the Colorado Central. In November 1877 he, Wolcott, and three other men organized the Denver and Rocky Mountain Railway Company. Popularly known as Hill's Road or the High Line, the enterprise proclaimed its intentions of laying track from Denver to Black Hawk, Central City, Georgetown, and Caribou, then across the state to the Utah border. In January a Denver newspaper reported that the directors of the smelting company had agreed to finance the project. Almost simultaneously, Hill purchased a wagon road between Idaho Springs and Georgetown for part of the route, set surveyors to work, and sent Wolcott to Boston to assist the eastern management in raising money.[6]

Businessmen at Central City and Georgetown were enthusiastic about Hill's Road, but their ecstasy was short-lived. In March, rumors appeared that Loveland had capitulated and the High Line would not be built. A spokesman for Hill denied the report as hearsay, but a Denver newspaper soon published a story claiming that Jay Gould and Sidney Dillon of the Union Pacific Railroad, which controlled the Colorado Central, had assured the smelting enterprise that Loveland's firm would make concessions for carrying ores to the new plant.

Events proved that the newspapermen were indeed correct. Final details were not arranged until May, but in the meantime Hill and Loveland negotiated a tentative agreement that they forwarded to Gould and Dillon for approval. Loveland still refused to lay the third rail between Denver and Golden, but he did agree to shift ore cars from narrow-to broad-gauge tracks at the expense of the railroad. This eventually proved so costly that the company added the additional track. Loveland also agreed to lay a third rail from his depot in Denver to the plant site so that coal, ores, and building materials arriving on other narrow-gauge lines could be shipped directly to the smelter. With the signing of this protocol the Denver and Rocky Mountain Railway passed into oblivion. Sullen over his defeat by Gould and Dillon, Loveland claimed that Hill's Road would have been little more than a feeder to the Colorado Central, but Gould and Dillon obviously failed to see it that way.[7]

Confident the railroad question would be resolved in their favor, Hill and his colleagues began searching for a new smelter location even before reaching an agreement with Loveland. In January 1878 Hill inspected potential sites on the outskirts of Denver. Then, after purchasing a plot on the corner of Fourteenth and Welton Streets, where he later built a spectacular house in the Second Empire style, he opened negotiations for an industrial tract just north of the city. The talks continued for a while, but when the owners refused to lower what Hill thought to be an exorbitant price, he broke off discussions. At this point the editors of the *Daily Times* warned that the high cost of real estate might persuade Hill to accept Loveland's suggestion to erect works in Golden. The danger was no doubt exaggerated, for Hill recognized Denver's superiority as a reduction center, but the fear prompted the Board of Trade to express its "disapprobation" of land speculators and its appreciation of the company's plans. Hill eventually resumed

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negotiations, and in April he spent $7,000 to acquire eighty acres of land just north of Denver, a tract bordered by the Colorado Central Railroad. In a classical mood befitting the Gilded Age, he and Pearce named the place Argo after the mythical vessel that carried Jason in search of the Golden Fleece.

Then came plans for the new smelter. Robert S. Roeschlaub, a noted Denver architect, designed the new plant with the assistance of Hill and Pearce. They intended to erect four major buildings—an ore house, a smelting plant, a coal house, and a refinery—as well as smaller workshops for carpenters, blacksmiths, and machinists, plus a two-story office tower at the front of the works. Spurs from the Colorado Central Railroad would enter the plant and connect the principal buildings and storage areas. Because of the fire hazard, Hill and Roeschlaub wanted to use brick as the primary building material, but as it was in short supply they switched to stone quarried at Morrison, a few miles south of Golden. They also selected corrugated iron for roofing. The plans called for the entire plant to be surrounded by a stone wall eight feet high. Outside the enclosure Roeschlaub designed a village with a hotel, church, school, and tenement houses. Argo would be a company town.

The new plant took shape during the spring and summer. Leaving Henry Wolcott in charge of operations at Black Hawk, Hill established temporary headquarters at Roeschlaub's office in Denver. In May he placed an advertisement in the *Daily Times* asking contractors to submit bids for brick and stone. As soon as Loveland's crews finished the third rail to Argo, the successful bidders shipped building materials by the carload to the construction site. By summer more than a hundred men were at work on the plant. When Hill gave city officials a tour in September, the major structures were in place, machinery lay on the grounds, and ores were piling up for reduction.[8]

The Argo smelter commenced operations on January 1, 1879, even though it was still unfinished. During the next few months Pearce and Wolcott pushed construction at a rapid pace, but work on the refinery went slowly because the enterprise took special precautions to preserve the mechanics of

Pearce's secret process. Not until the end of the year did the plant become fully operational. By then the firm even had its own steam engine to run between Argo and Denver and do switching at the works. During its first twelve months in operation the smelter's production of gold, silver, and copper rose to $2,450,000. This was a new high for the company, but it marked the last time Hill's output would be the largest in Colorado's reduction industry.[9]

The cost of relocation had been high. At the annual meeting in Boston in May 1879, James W. Converse, the firm's president, reported that debt had risen to $262,000, more than half the outstanding equity capital. To provide the smelter with additional working funds and reduce the huge financial obligations to a more acceptable level, the stockholders voted to double the capitalization from $500,000 to $1,000,000. They authorized the creation of 5,000 new shares of stock, which the enterprise sold within a year. The officers used part of the money to reduce liabilities. Hill took advantage of the opportunity to increase his holdings from 520 to 1,040 shares, displacing J. Warren Merrill, the corporate treasurer, as the largest stockholder.[10]

As Argo took shape on the north Denver plain, Hill took advantage of the firm's success to advance his political career. In May 1878 Jerome B. Chaffee announced that because of poor health he would not be a candidate for reelection to the United States Senate. No sooner had he made his decision public than it was rumored that Hill had decided to seek the seat. These rumors proved true. To spearhead his drive for the Republican nomination, Hill purchased a newspaper at Central City and filled the party coffers during the fall campaign. In the November election the Republicans won a majority of seats in both houses of the state legislature, thus making their nomination tantamount to election. A month later Hill emerged as the front-runner for Chaffee's seat, his drive headed by the Wolcott brothers, the new state senators from Clear Creek and Gilpin counties.[11]

As the leading Republican candidate, Hill became the target of vituperative attacks by the *Rocky Mountain News*, which

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was controlled by the future Democratic nominee, William A. H. Loveland. The paper sarcastically referred to Hill as the "Argo statesman" and accused him of numerous misdeeds and of spending the excessive sum of $15,000 during the fall campaign. The *News* also claimed that Hill had the support of the Atchison, Topeka, and Santa Fe Railroad, which wanted to control a senate seat in order to secure favorable legislation. When Hill unwisely attempted to purchase the paper in an effort to silence the criticism, the editors jeered that it could "be had at ten dollars a year, which is just as near as Mr. Hill will ever come to owning it."[12]

Despite the partisan attacks of the *News*, Hill's campaign for nomination and election went smoothly. When the Republicans caucused on the evening of January 9, 1879, Hill led the balloting from the outset and received the nomination on the fifth poll, besting his two nearest opponents, George M. Chilcott and Senator Chaffee, who at the last minute had decided to make the race. With Hill's election certain, the *News* could do little more than proclaim: "The Political Doom of Senator Chaffee Hermetically Sealed." When the general assembly convened several days later, Hill easily defeated Loveland. After both houses met in joint session to declare Hill the victor, he was formally introduced and made a short speech. In congratulating the senator-elect, the *Engineering and Mining Journal* commented that if he ran Colorado politics as well as he did his smelting enterprise, there would soon be "a moral dividend to declare, instead of the usual assessment."[13]

When Hill left to assume his duties in Washington, the day-to-day management of the Argo smelter fell to Richard Pearce and Henry Wolcott, and their leadership proved able indeed. They increased production from $2,500,000 in 1879 to $4,400,000 in 1884. The growth primarily reflected the rising output of mines situated along the South Clear Creek, in Summit County, and at Leadville, but the firm also purchased ores from markets in Utah, New Mexico, and Montana. South Park and Boulder County declined as sources of mineral, but small consignments shipped from Arizona, Nevada, and northern Mexico more than made up the difference. Although the mines of Colorado remained the smelter's chief supplier, the railroads linking the ore-producing regions of the West permitted the enterprise to serve a wide area, as Hill and his colleagues had foreseen.[14]

More than other mining regions outside Colorado, Montana remained essential to the firm's livelihood. Copper was the sine qua non in the Swansea process, but during the seventies it had grown scarcer in Hill's traditional markets on the forks of Clear Creek. Beginning in 1878, William A. Clark had shipped large quantities of copper ores from his mines in Butte to the furnaces at Black Hawk. Yet this arrangement had never proved satisfactory because transportation costs, amounting to forty dollars per ton, had eroded the profit margins of all concerned.[15]

Perceptive as they were, Hill and Clark recognized that smeltermen would soon erect plants in Butte. Copper production there was on the rise even though the Anaconda bonanza was still unknown. Hill and Clark wanted to steal a march on expected competition. Early in 1878, while the Argo smelter lay in the initial stages of construction, Hill sent Henry Williams, the manager of the Alma plant, to Montana to determine the feasibility of erecting works in Butte. Williams spent several weeks inspecting mines, locating building materials, and searching out sources of fuel and water. When he returned to Denver, he reported that prospects for a smelter were excellent.[16]

In June 1879 this report and the need of the Argo works for steady supplies of copper prompted Hill, Pearce, Henry Wolcott, Williams, and Clark to organize themselves into a body corporate as the Colorado and Montana Smelting Company. Six months later, after several unaccountable delays, they filed the articles of incorporation with the secretary of state in Denver and set the capitalization at $200,000, the same as the Boston and Colorado firm in 1867. Hill was elected president of the company even though he now held a seat in the United States Senate, and he purchased one-fourth of the two thousand shares issued. The remainder was not subscribed for another three years. Williams was appointed manager of the

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project and promised a fifth of the capital stock if he made the enterprise a success. Yet it was privately reported that he distrusted Clark's motives.[17]

With the company organized, Williams returned to Butte. He purchased the property of a defunct smelting firm, erected new furnaces along the banks of Silver Bow Creek, and began reducing Clark's ores to a matte averaging 50 percent copper and worth from $600 to $1,000 per ton depending upon the silver content. This he shipped to Argo for refining. As time passed, Williams increased the smelting capacity from eighteen to fifty tons a day and purchased ores from other mineowners. He reduced some consignments in Butte but shipped others directly to Colorado. When new companies erected smelters in Butte, he bought their matte for shipment to Argo. Although the two enterprises never merged into a single corporation, they remained closely associated—another example of the informal integration prevailing in the reduction industry.[18]

While operations went forward at Butte and Argo, the Boston and Colorado enterprise witnessed the appearance of a potentially dangerous rival. In 1881 a group of investors from Denver organized the Miner's Smelting and Reduction Company, which purchased and renovated a defunct smelter in Golden. Using a time-honored industrial subterfuge, the firm hired several of Hill's employees in order to obtain the details of Pearce's secret process and other techniques employed so successfully at Argo. The Miner's Company put its smelting furnaces into operation by summer, produced some matte, and extracted silver by the Ziervogel method. Then the metallurgists melted the gold-copper residue into a high-grade matte, the first step in Pearce's technique. Several weeks later Edward O'Niel, one of Hill's former employees, finished installing the equipment that duplicated the entire Argo method.[19]

Using this technology, the Miner's enterprise remained in business for another two years. It expanded operations at Golden, established sampling agencies in Black Hawk, Idaho Springs, and Georgetown, and lured more employees away from Hill's firm. Yet in spite of its technical success it failed in

1883, a victim of stiff competition and poor location. The *Engineering and Mining Journal* noted that the plant was situated in "an out-of-the-way place and could not compete with one more centrally located and with six times the capital," a lightly veiled reference to Hill's company, which once again had triumphed over a rival in the Clear Creek ore markets. To restore its monopoly on Pearce's process, the Argo firm purchased and razed the Miner's plant.[20]

Despite his continued success Hill saw the position of his enterprise change markedly. After more than a decade as the only viable smelter in Colorado, its production was surpassed in 1880 by the Grant works in Leadville. Even more significant, the swift development of silver-lead smelting on the North Arkansas thrust blast furnaces to the fore as the chief means of ore reduction in Colorado. Hill's company remained important for another three decades, but leadership in the industry had passed to the silver-lead entrepreneurs.

Hill and his associates had smelted ores at Argo for more than three years when fire destroyed the Grant works at Leadville in May 1882. This catastrophe threw the owners, Edward Eddy, William H. James, and James B. Grant, into consternation. Yet they were a resourceful group of men, and they had access to capital with which to rebuild. The question was where? Even before the conflagration, they had debated the possibility of relocating in Pueblo, at the foot of the Arkansas Valley. Here they would enjoy proximity to the coking coals of Trinidad and access to a good railroad system. Yet other considerations pushed Denver to the forefront in their thinking when the time came to rebuild the Leadville plant. Ever since he had gone into business in 1878, Grant had shipped his bullion to Omaha. In return, he had received preferential freight rates from the Union Pacific Railroad, whose president, Sidney Dillon, held a large block of stock in the Omaha Smelting and Refining Company. This was the key to the decision of Eddy, James, and Grant. They wanted to maintain their favorable relationship with the line and still lie on the most direct route from Leadville to Omaha. For this reason they decided to rebuild in Denver.[21]

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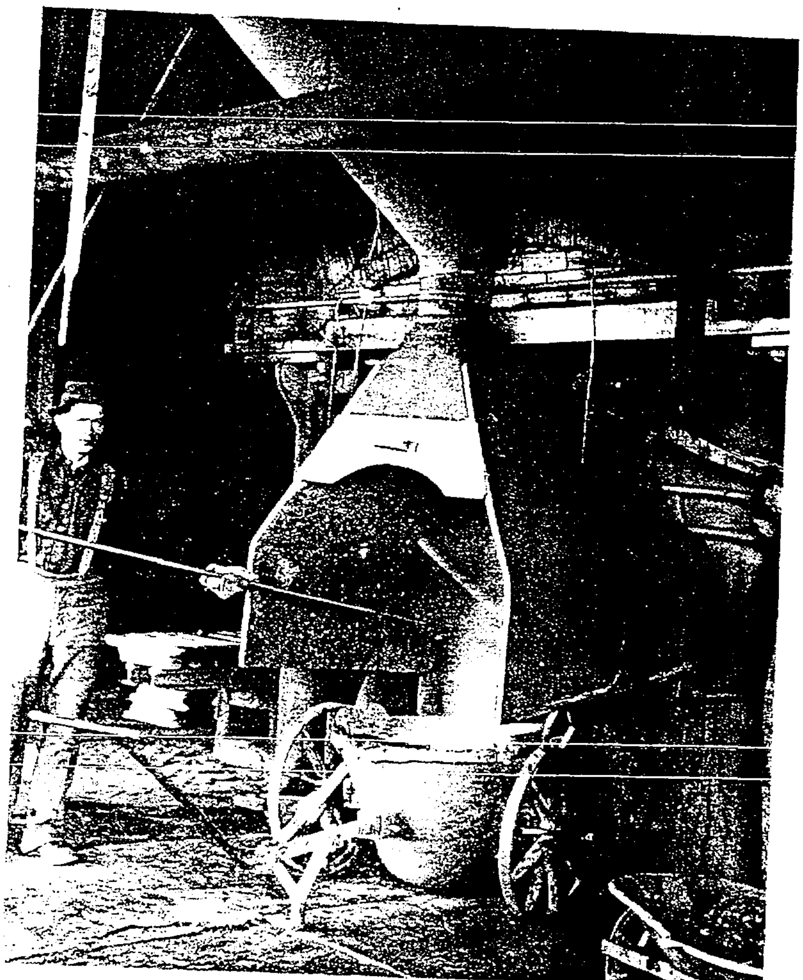
After looking at several possible locations, Grant and his partners bought an industrial tract about two miles northeast of downtown and across the South Platte River from Argo. The land itself formed a terrace that sloped gently toward the waterway, and Grant and Malvern W. Iles took advantage of the contour when they designed the smelter. Their plans called for a system of railroad tracks laid in such a way that ores, fuel, and flux would be delivered directly to the upper levels opposite the charging doors of the furnaces. Then, in the course of operations, intermediate products would flow downhill to lower levels. Ultimately, smelter workers would run slag onto a dump and load bullion onto cars bound for Omaha.

Eddy, James, and Grant broke ground for the plant on July 2, 1882, and Denver's second great smelter took shape during the summer and fall. The partners purchased the best machinery and furnace equipment available from Fraser and Chalmers in Chicago, the Pacific Iron Works of Leadville, and the Colorado Iron Works of Denver. Grant hired crews of tradesmen who put up the brick and stone buildings, installed electric lights, and put in the most advanced technology of the day. Iles supervised all technical details. As work progressed, Eddy and James began shipping ores down from the mountains via the Denver South Park & Pacific Railroad. Huge stocks of fuel and mineral accumulated on the grounds as the smelter neared completion. After four months of steady work, Grant and Iles blew in the first reduction unit on October 7. Others followed in rapid succession, and by early November the plant was in full operation with eight blast furnaces, which had an ore capacity of 230 tons daily.[22]

Just as the smelter came on stream, however, Grant had to divert his energies from business to government; for, like that of Nathaniel P. Hill, his political star was ascendant. During the summer of 1882 the leaders of the Democratic party urged Grant to run for governor. His success in business had made him well known throughout the state, and party stalwarts wanted a strong gubernatorial candidate because they saw an excellent chance of winning in November. Grant was amenable to the idea. At the county conventions held during the late



Smelter worker drawing slag from a furnace at the Grant smelter in Denver. Harry H. Buckwalter, photographer. Colorado Historical Society, Denver.

summer, his supporters easily won majorities that led to his nomination as the Democratic standard bearer.

In sharp contrast to Grant's harmonious nomination, the Republican aspirants for governor created acrimony within the ranks of the party. The infighting at the county and state con-

ventions split the politicians into two
Wolcott group, known as the Argonauts
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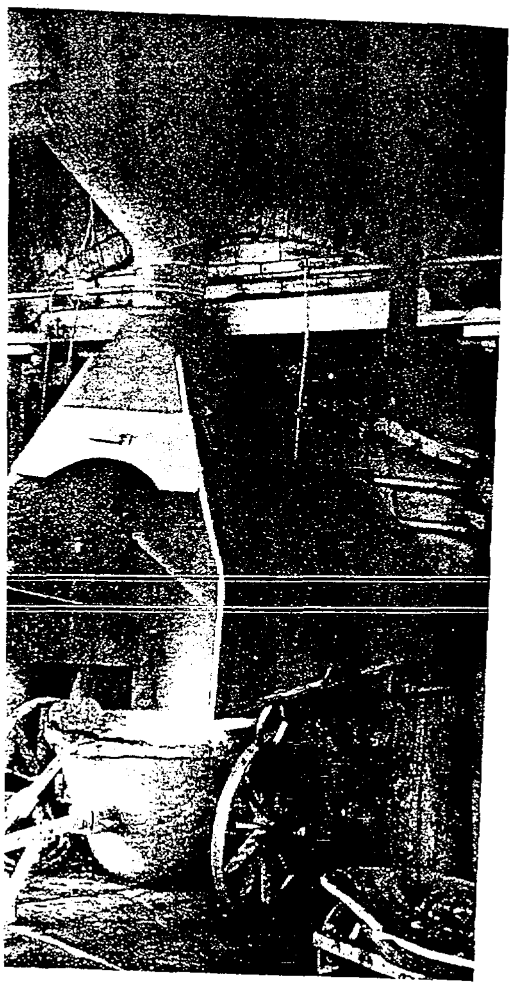

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ventions split the politicians into two factions—the Hill–Wolcott group, known as the Argonauts because of their association with the famous smelter, and the Jèrome B. Chaffee–Henry M. Teller group, known as the Windmills because of their alleged boastfulness. The Argonauts supported Hill's right-hand man, Henry Wolcott, but the Windmills blocked his drive and nominated their own candidate, Ernest Campbell of Leadville. This worsened the disharmony between the two camps, and the Argonauts refused to support Campbell, thus setting the stage for a Democratic victory. Neither Grant nor Campbell waged an energetic campaign that fall; but when the votes were counted in November Grant found himself elected the first Democratic governor in Colorado's history.[23]

Even after he took office, Grant, like other businessmen in the Gilded Age, hardly let his public career interfere with his entrepreneurial activities. This was all to the good, for even as he assumed the governor's chair his firm was on the eve of major changes. Early in 1883, Eddy, James, and Grant began to explore the possibility of merging their enterprise with the Omaha Smelting and Refining Company. What motives lay behind this move remain conjectural, but the forces promoting the talks must have included a desire to integrate operations from sampling through smelting to refining, broaden ore markets, take advantage of the economies of scale, and raise capital. Talks ensued in the spring and summer, correspondence flowed across the plains, and lawyers delved into legal matters. Then negotiations culminated on July 5, 1883, with the creation of the Omaha and Grant Smelting and Refining Company. This firm acquired all the property of its predecessors as well as the sampling works of Eddy, James & Company, the "company" of course being James B. Grant.

The merger united some of the most important entrepreneurs in the industry—Eddy, James, and Grant of the Colorado firm, and Guy C. Barton, Edward W. Nash, Charles Balbach, and Joseph H. Millard of the Nebraska corporation. They set the capitalization at $2,500,000 and specified in the corporate charter that the enterprise could not go into debt beyond two-thirds of its equity capital and that the stock could not be

James B. Grant about 1882, when he was elected governor of Colorado. Colorado Historical Society, Denver.

increased to more than $5,000,000. Barton became president, Grant vice-president, and Nash secretary and treasurer. As a practical matter, Eddy, James, and Grant would handle all operations in Colorado.[24]

From the outset Barton, Grant, and their associates bent their energies to rationalizing operations and increasing the scope of their activities. First they rerouted ore shipments so that the Grant works in Denver received the bulk of the mineral under contract with shippers in Colorado. This lowered costs and permitted the Omaha smelter to concentrate on the ore markets of Utah, Montana, and Idaho. The firm also opened sampling agencies in Black Hawk, Aspen, and other camps to go with the plant at Leadville. And to further integration in

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Denver, Grant and his colleagues built a sampling mill and a number of roasting furnaces with which to treat the rising production of sulfides.[25]

The firm also moved heavily into the Leadville ore market, which furnished about 60 percent of the mineral smelted at the Grant works. From 1882 through 1884 Eddy, James & Company bought ores whose value exceeded the production of every smelter remaining on the North Arkansas! Purchases became so extensive that they exceeded the capacity of the Denver smelter to process what the sampler had put under contract. To process the ores, the enterprise spent a reported $150,000 to acquire the plant of Cummings and Finn, who had erected one of the largest smelters in Leadville. Eddy, James, Grant, and one Henry Head incorporated the property as the Fryer Hill Smelting Company, although it remained a subsidiary of the Omaha and Grant Company.[26]

Operations in Leadville went well for a time, but in 1885 Grant and his colleagues found themselves beset with problems. Despite its size and strength the Omaha and Grant enterprise found itself unable to compete with the Pueblo Smelting and Refining Company for mineral high in lead. Rather than purchase ores at a loss, Grant and his colleagues withdrew from this phase of the market, but this meant they had to close the Fryer Hill plant. By the time the Pueblo smelter relinquished its hold on the market, Barton and Grant had enlarged both the Denver and the Omaha works. That made the Fryer Hill plant expendable, and it never reopened. Barton and Grant later leased the property to contractors who reworked the slag dumps to recover small amounts of silver and lead lost in the early days of processing.[27]

The closing of the Fryer Hill smelter hardly put a crimp in overall operations, but the experience still left a good measure of anxiety in the minds of Grant and his colleagues. With the production of dry ores increasing everywhere, they worried that future prosperity might be impaired if they failed to guarantee their plants a reliable source of lead. For this reason the Omaha and Grant Company bought the Terrible mine in Leadville for a reported $100,000, and metallurgists in Denver and Omaha were soon adding the concentrates to other ores "like yeast to the dough." The Terrible mine never provided enough lead to support the massive operations of the firm, but it provided some flexibility in a capricious ore market.[28]

By 1886 the Omaha and Grant Company had emerged as a highly integrated firm. It owned one mine outright, many sampling agencies, two reduction plants, a refinery, and a marketing arm well on its way to product differentiation with its brand, "Omaha lead." What was more, Eddy, James, and Grant, as well as their associates in Nebraska, owned large blocks of stock in many mining corporations, thus continuing the thread of informal integration seen throughout the smelting industry.

The success of Grant, Hill, and their associates drew the city of Denver to the attention of other entrepreneurs. One was Edward R. Holden, another his partner Richard Cline; still a third was Malvern W. Iles, and a fourth was Arthur Chanute. Each of these men had a different perspective on the reduction business. In Leadville Holden and Cline owned a prosperous ore purchasing agency through which passed large quantities of mineral destined for local works or the valley smelters. This gave Holden and Cline a broad perspective on the mining industry, just as it had Edward Eddy, William H. James, and August R. Meyer a few years before. Iles possessed the great metallurgical skills that had made so large a contribution to the prosperity of Grant's smelters and to the technological evolution of the industry. Yet, like Anton Eilers and Alfred W. Geist before him, Iles desired an entrepreneurial role. And Chanute was a prosperous Denver banker closely connected to the financial community in Omaha. Each of these men saw continued potential in the growth and prosperity of the silver-lead industry, and early in 1886 they organized the Holden Smelting Company.

Then came the questions of location and design. Denver was an ideal site. Both Iles and Chanute had business connections there, and the city now had even better railroad service than it had when Hill and Grant put up their plants. And so Denver was selected. Using capital probably raised by himself and

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Chanute, Holden acquired about thirty acres of land near the Grant works. Then Iles, drawing upon his great experience and his knowledge of the latest advances in technology, designed an integrated smelter that was to be the most efficient of its day, a reputation it held well into the twentieth century. Since Iles had helped plan the Grant work, it was not surprising that his new structure resembled the older plant, although his design called for far more mechanization to reduce costs.

While Iles and Chanute did their work in Denver, the voluble Holden toured the mining camps in the high country, negotiating contracts for mineral. As might have been expected of an old ore buyer, he was energetic and successful. The first shipments of rock began arriving on the smelter grounds in May, several months before Iles planned to blow in the smelting furnaces. In the search for mineral, the mines of Leadville were particularly important to the firm—as they were to all the valley smelters except Hill's works at Argo—and the enterprise had the good fortune to enter the Leadville market just when the Pueblo Smelting and Refining Company lost its corner on high-grade galena. This later proved permanent, but Holden and his colleagues could not then be sure. To guarantee themselves adequate supplies of lead, they bought the Silent Friend mine in the Monarch district of the Arkansas Valley.

Meanwhile, Iles pushed construction along steadily during the summer and into the fall. The firm acquired good supplies of ore, iron flux, and El Moro coke, then in September Iles set the first smelting unit in blast. He added two more in October and a fourth in December. Excellent planning made operations go smoothly from the beginning, and by the end of the year the Holden smelter had shipped bullion worth nearly $533,000 in silver, gold, and lead, a creditable showing in so brief a period.[29]

For reasons that have always remained obscure, Holden and his associates waited until nearly six weeks after beginning operations to incorporate the new venture. Not until October 26 did Holden, Cline, Iles, and Chanute, as well as John L. McNeil and Samuel Adams, set their hands and seals on the articles of incorporation and fix the capitalization at $300,000. Of this amount they used about $200,000 to acquire property—meaning the reduction plant—and the remaining $100,000 went to provide working capital. They also elected Holden president of the corporation.[30]

With such a propitious start, Holden and his colleagues expanded and integrated their operations further in the course of 1887. Much of the actual work fell to Malvern W. Iles. He directed the construction of a mill for crushing ores and matte, built additional roasting units, and installed two more blast furnaces, giving the works a total of six, with an aggregate capacity of three hundred tons daily. Iles also experimented with a new process for treating zinc-bearing minerals excavated largely at Leadville, where miners were finding these ores in massive quantities as they blasted ever deeper into the earth in search of silver and lead. He had little success, but his efforts presaged the day when the industry would process huge amounts of zinc-bearing rock. The company also purchased another fifty acres of land where the Colorado Central Railboard built several miles of sidetrack to aid the movement of ore and fuel.[31]

These improvements augured well for future prosperity; yet in the midst of expansion there were significant shifts in management and ownership. As in any business enterprise, growth required substantial infusions of capital, and Holden and his colleagues borrowed much of what they needed from the Colorado National Bank. At the same time—and perhaps as a condition of the loans—two major figures in the banking industry, Dennis Sheedy and Charles B. Kountze, acquired large blocks of stock in the company. They saw Holden as a promoter and speculator, a reputation he also had in mining and smelting circles. Sometime in 1887, Holden sold a substantial quantity of stock to Meyer Guggenheim, a Leadville mineowner, and the two men later announced plans to build still another smelter in Denver. This only served to convince Sheedy, Kountze, and others that Holden could not be trusted, particularly since he was letting the potential competitor Guggenheim study the internal mechanics of operation. But,

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what was worse, Holden's management had now brought the company to the verge of bankruptcy. Kountze had Sheedy determine if anything could be done to save the enterprise and protect the loans of the bank. And Sheedy concluded that the only thing for them to do was to take over the management. As a result, at a special meeting the directors elected Sheedy president of the corporation and as a face-saving gesture relegated Holden to the position of general manager. Soon after, Holden sold his remaining interest and left the firm entirely to join Meyer Guggenheim.[32]

By his own admission, Sheedy "knew nothing of smelting or ores"; yet this stout, moustachioed man with a receding hairline had been very successful in business. Though born in Ireland in 1846, he had grown up in the United States, first in Massachusetts and later in Iowa. He had relatively little formal education, but he had risen through clerking, freighting, merchandizing, cattle raising, and banking to a position among the wealthy in Denver. He was a self-made man in the classic mold of nineteenth-century individualism. When he became president of the Holden Smelting Company, he "realized that to accomplish anything he must master the details of the industry." Right away he hired a tutor, and for the next three years he pursued his "incessant study," reading every book available to acquire a technical and practicable knowledge of the business. "Night after night" he studied, and day by day he managed.[33]

Once Sheedy took command, he and his colleagues reorganized the firm as the Globe Smelting and Refining Company. In the new managerial structure Chanute became vice-president, John M. Walker secretary and treasurer, and Iles superintendent of the works. The new directorate included Chanute, Walker, Herman and Charles B. Kountze, Thomas H. Woodelton, William B. Berger (Hill's son-in-law), and Sheedy himself. Iles lost his seat on the board, but he remained with the firm and proved essential to its success in the years ahead. Sheedy's group also increased the capitalization to $1,000,000 and began a new town known as Globeville for their workers. Later annexed by Denver, this community, inhabited increasingly by people of eastern European origin, became one of the most famous ethnic neighborhoods in the city. Polish, German, and Slovenian tongues resounded in the plants, for some workers spoke not a word of English. And Slavic churches later were built as the newer immigrants tried to re-create the customs and traditions of the old country. In more ways than one, the Globe smelter justified its name.[34]

Under Sheedy's leadership the enterprise sought out minerals along the eastern slope and in central Colorado. It invaded markets on the forks of Clear Creek and competed effectively with its rivals in Denver and Pueblo for the output of the Mattie, Lamartine, and other properties. The firm also drew heavily on Leadville, still the leading mining camp in the high country, an effort that put further pressure on the companies still in business there. Sheedy's firm became one of the first smelting enterprises to process mineral drawn from the Moyer shaft of the Iron Silver Mining Company, which had developed this new bonanza drift as older ore bodies gave out. Then as the Colorado Midland and Rio Grande railroads looped around the mountains from Leadville to Glenwood Springs and on to Aspen, the Globe Company tapped large quantities of mineral from Pitkin County, which went into its boom years in the late eighties because of cheaper transportation and access to the Leadville and valley smelters. The mines on Aspen Mountain and nearby peaks produced riches that even surpassed Leadville for a short time in the early nineties. The Globe plant was both a cause and a beneficiary of the boom.[35]

Sheedy and his colleagues enjoyed much success in the mining camps of Colorado, but opportunity—and necessity—drove them to faraway ore markets, something made possible only by rail transport. The charter of the old Holden firm had specified that the company would tap mines in New Mexico, Utah, and Idaho, whose districts grew in importance as time passed and the smelter expanded. Idaho proved particularly significant because the newly opened properties in the Coeur d'Alene country, notably the Bunker Hill & Sullivan and the Tiger-Poorman, offered large quantities of mineral relatively low in silver but high in lead. Because the Silent Friend mine in

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Colorado failed to provide the plant with enough base metal, Sheedy and his colleagues sought the Idaho product to mix with dry ores coming down from Leadville, Breckenridge, and other camps.

For this very reason the Republic of Mexico emerged as an important source of mineral. The Mexican rail system had grown at a slower rate than its American counterpart, but it nonetheless carried increasing quantities of high-grade galena north to border towns like El Paso, Eagle Pass, and Laredo, Texas, there to be shipped farther north to the Globe smelter and its rivals. At first, about 1884, the ores came in a trickle—to use an incongruous metaphor—but by the early nineties Mexican mineral had grown so important to Sheedy and his company, and the whole industry, that he hired Henry Raup Wagner—a Yale graduate trying to avoid family pressures to pursue a career in law—to coordinate the firm's multifarious operations in Mexico. Wagner did such outstanding work that he advanced rapidly through the corporate ranks and later emerged as an important figure in the industry before turning from "bullion to books," as he wrote many years later.[36]

Having prospered for several years, Sheedy and his associates formulated plans to integrate operations even further by building a refinery. When they announced their intentions in 1890, the editors of the *Engineering and Mining Journal*, which kept its eye on all phases of the minerals industry, wondered if the enterprise could acquire enough bullion to make such an addition profitable. The Globe's furnaces would never produce enough bullion by themselves, many other refineries were in operation, and the number of smelters was declining. Sheedy and his colleagues delayed construction for a time, but ultimately they were not bothered by the doubts of other people. In 1891 they borrowed $100,000, and the next year they broke ground for the refinery. Once operations commenced, the firm supplemented its own bullion production by reaching out to garner the production of smelters as far away as Washington and Mexico.[37]

By 1893 Sheedy's enterprise had emerged as one of the major forces in the smelting industry, the plant highly integrated, its operations farflung. With its sampling and crushing mills, roasting units, blast furnaces, and refinery, the operation in Denver was an efficient producer with costs among the lowest in the business. Sheedy's ore buyers crisscrossed the North American mining districts from southern Canada to central Mexico and from Colorado to California. And the abilities of Holden, Sheedy, and Iles in launching and managing the firm permitted the city of Denver to maintain its position as the most important smelting center in the industry.

Despite its rapid growth, the Globe enterprise never overtook its rival, the Grant smelter, as the largest producer in Colorado. Yet both evolved along the same path, and only a continuous process of expansion at the Grant works permitted the smelter and the city to maintain their claim to primacy in ore reduction.

Early in 1887, shortly after the Globe smelter came on stream, Eddy, James, and Grant began installing more roasting units, giving them a total of twenty-nine, with an aggregate capacity of three hundred tons of sulfides daily. The firm also enlarged six of its ten blast furnaces, increasing the smelting capacity to about four hundred tons daily. And it augmented the size of the dust chambers attached to the smelting units in order to capture larger quantities of metal volatilized in processing.[38]

Grant

Like Iles and his colleagues, Eddy, James, and Grant looked to new methods of reduction in hope of lowering smelting costs and augmenting ore supplies. During the summer of 1887 they explored the possibility of using petroleum drawn from Florence, Colorado, as an alternative source of energy in at least some of their operations. Experiments lasted several weeks, but the tests revealed that coal, coke, and charcoal were easier to obtain and more economical to use than "black gold." The next year Eddy, James, and Grant turned their attention to the possibility of reducing the zinc-bearing minerals that hampered the smelting of silver-lead ores. In conjunction with the Iron Silver Mining Company of Leadville, they erected an experimental mill in Denver to remove zinc from ores mined in

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the Iron Silver tunnels. The technique employed was a modification of the well-known Plattner process, a method that combined roasting, chlorination, and electrolysis to remove zinc and leave a residue ready for smelting. Both companies invested substantial amounts of capital in the venture, but the project proved financially unsound, and the mill had to be abandoned.[39]

Eddy, James, and Grant continued to draw heavily on the ore production of the Rocky Mountains. In gross tonnage Leadville remained their most important source of mineral. Even though carbonates had virtually disappeared from the camp's output, the smelter purchased huge quantities of sulfides from properties like the Ibex, Adams, and Silver Cord Combination. Like their rivals in the Globe Company, Eddy, James, and Grant entered the booming Aspen market once the Colorado Midland and Rio Grande railroads made it feasible to ship the production across the mountains and down to Denver. Grant even purchased bullion from the tiny works of the Aspen Mining and Smelting Company until the firm found it more profitable to sell rather than to process its own ores. In the early 1890s, as Cripple Creek, a new camp scarcely seventy-five miles southwest of Denver, emerged as the greatest gold producer in the Rocky Mountains, Grant and his colleagues found a new source of mineral for the furnaces in Denver. But this material fell into the category of dry ores, which compelled the enterprise to seek ever-larger quantities of lead-bearing ores outside Colorado.[40]

Like their counterparts working for other companies, the ore buyers of the Omaha and Grant enterprise reached aggressively into distant markets. When the Bunker Hill & Sullivan firm opened its great veins of silver-bearing lead in northern Idaho, Grant and his colleagues secured much of the output and had it shipped to Denver and Omaha, mixed with dry ores, smelted to bullion, and refined to metal. Representatives of the company also bought silver-lead minerals in Utah, Nevada, California, and New Mexico, and on one occasion they even purchased a small quantity of platinum rock mined in Wyoming. Reaching beyond the United States, Grant and his associates sent agents into Mexico, where they negotiated contracts for high grades of galena to be shipped north and mixed with American production. Yet, because of the close relationship the firm maintained with the Bunker Hill & Sullivan and other shippers in Idaho, the Omaha and Denver smelters never became as dependent on Mexican minerals as some of their rivals.[41]

During these years the Omaha and Grant Company enjoyed a large measure of prosperity. From the time of its organization in 1883 through the end of 1890, profits flowed into the treasury, some to be reinvested in the business, some to be paid out in dividends. The Denver plant earned $2,095,000, the Omaha works another $1,614,000, for a total of $3,709,000. From the returns Grant and his colleagues reinvested $1,100,000 in the enterprise, used another $707,000 to pay interest on working capital, and paid out $1,900,000 in dividends. For comparison, the nominal capitalization of the firm was $2,500,000.[42]

In the early 1890s Grant and his associates decided on an ambitious program of expansion; but having taken this decision they found themselves needing an estimated $1,000,000 in new capital. They wanted to renovate both the Denver and the Omaha plants and erect an electrolytic copper refinery at the Nebraska works to separate copper matte evolved as a by-product in the smelting process. The key question facing Grant and his colleagues was this: Should they issue preferred stock or should they sell bonds? They debated the alternatives for some time, finally settling upon a foray into the debt markets.[43]

So large a bond issue, however, could be sold only through investment bankers in the East. After approaching a number of companies, Barton, Grant, and their colleagues agreed to let the underwriting to the firm of Clark, Dodge & Company, a prominent financial house in New York. This enterprise in turn approached Lee, Higginson & Company in Boston, and Blake, Boissevain & Company in Amsterdam. With the New Yorkers taking the lead, the general partners in each concern made a thorough investigation of the Omaha and Grant enter-

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prise. They looked at profits and prospects, projected growth rate, liabilities, values of plants and other properties, and the articles of incorporation. The record impressed the bankers, and they agreed to market the bonds with an annual interest coupon of 6 percent. In return, the Omaha and Grant firm placed a mortgage on its two plants to guarantee the securities, which it expected to pay off in twenty years. The underwriting syndicate worried about a weakness developing in the financial markets of Europe, where they intended to place some of the bonds, but by the end of 1891 Clark, Dodge and Company were ready to sell the securities in New York, Boston, Amsterdam, and London. The smelting enterprise received the money it needed the next year.[44]

Grant and his colleagues then launched their new program. First they had to reincorporate the enterprise, because the existing charter prevented the company from embarking upon certain avenues of expansion. On January 23, 1892, Eddy, James, and Grant, along with Barton, Nash, and others, reorganized the venture as the Omaha and Grant Smelting Company. They kept the capitalization fixed at $2,500,000, but the new charter permitted the enterprise to acquire coal mines, stone quarries, and ore-producing properties and to sell stocks, bonds, and other securities as well as to purchase those of other firms. Then the firm allotted its new cash: $100,000 for the copper refinery in Omaha, $400,000 for improvements to the Grant works in Denver, and $500,000 for additional working capital and the purchase of property. When completed, these improvements enhanced the firm's position within the industry; yet this round of additions came on the eve of hard times that, paradoxically, would open new opportunities for the company.[45]

As Denver's two silver-lead smelters prospered under the leadership of Holden and Sheedy, Barton and Grant, the Boston and Colorado Smelting Company maintained its strong position under the hand of old and new management. In 1885 Nathaniel P. Hill ran for reelection to the United States Senate but lost his bid for a second term partly as a result of the ongoing feud between the Argonauts and the Windmills. Bitter in defeat, he decried the "notorious corruptionists of large experience" who had precipitated his downfall, but this was little more than a slap at the winner, Henry M. Teller. Nonetheless, Hill returned to Colorado to direct the fortunes of the smelting company and undertake other business ventures. Two years later Henry Wolcott resigned as manager of the Argo smelter to pursue his many interests in mining, at which he was very successful, and to continue his political career, at which he was very unsuccessful—he lost a second bid for the governorship. With Wolcott's departure after nearly two decades with the enterprise, Hill named Richard Pearce manager of the Argo works. Crawford Hill and Harold V. Pearce also entered the firm's service about this time. Both worked largely as assistants to their fathers, whom they eventually succeeded.[46]

New faces also appeared in the eastern management. During the eighties the presidency passed from James W. Converse, chief executive of the enterprise since its inception in 1867, to J. Warren Merrill, Joseph Sawyer, and finally Costello Converse, son of the original president. New individuals from the Boston area took seats on the board of directors. Yet Hill himself continued to be the largest stockholder, though he never held a high corporate office.

The background of the work force also changed during this time. In earlier years Hill had hired American-born workers to supplement a few men who had emigrated from Swansea, but now he and his managers began to hire people from other parts of Europe, a very large number coming from Scandinavia, particularly Sweden, in contrast to the southern and eastern Europeans going to work in the Globe and Grant smelters. Yet, as Hill remembered later, he was careful not to hire too many men from any one country lest this create a clannishness that might prove inimical to the interests of the company. Many workers continued to live in the tenements or small houses that the company built, and their children went to school across the river in Globeville with the children of smelter workers at the Grant and Globe plants.[47]

Despite these changes, Richard Pearce continued his longstanding efforts to increase the size and efficiency of the

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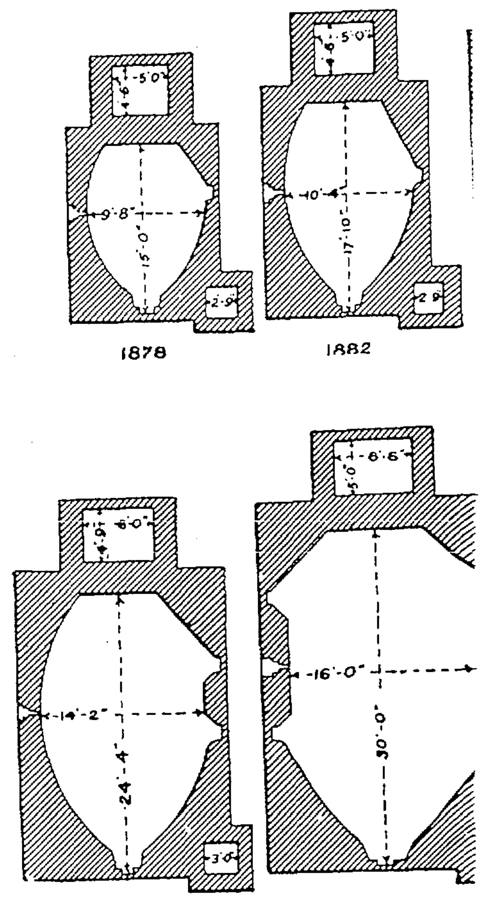

Fig. 5. Reverberatory development at Ar
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reverberatory furnaces. When Hill and his colleagues opened the plant in 1879, each smelting unit had an ore capacity of about twelve tons a day, the largest size then in use. But as the years passed these models proved inadequate because minerals

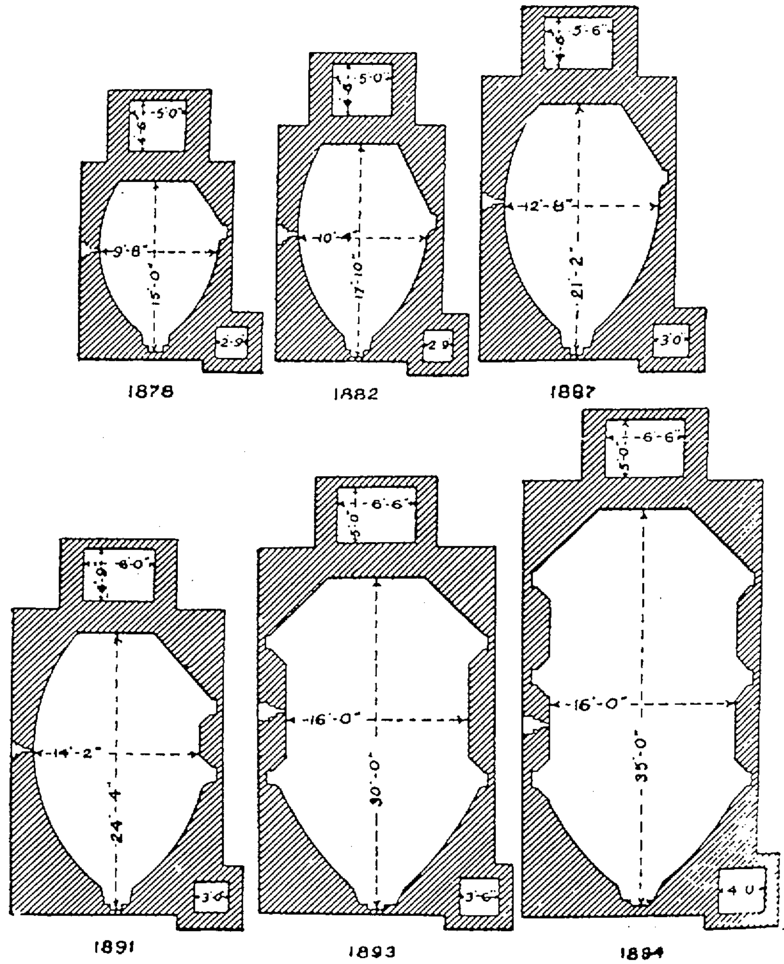

Fig. 5. Reverberatory development at Argo. By increasing the furnace dimensions, Richard Pearce enabled the smelter to reduce more ores at lower cost. Reproduced from Peters, *Modern Copper Smelting*, 7th ed.

declined in grade, silver-lead smelters competed for pyrites, and dry ores offered a new source if the firm could lower its costs. All this called for greater unit smelting capacity. Pearce responded by extending the length and width of the hearth and increasing the size of the firebox and smokestack. These modifications increased the daily capacity of each furnace to seventeen tons in 1882, twenty-four tons in 1887, thirty-five tons in 1891, and fifty tons in 1894. Pearce also began sending intermediate products directly from the roasters to the reverberatories instead of allowing the materials to cool for sampling and mixing, the normal practice in times past. Such economies of scale permitted the firm to lower its unit costs for fuel and labor and naturally translated into lower reduction costs per ton of ore.[48]

The new furnaces, however, presented Pearce with new challenges. The common practice for removing slag was to skim it from the surface of the molten matte and run it out through the slagging door. But the larger furnaces produced such enormous quantities of waste material that they created problems not seen in the past. If workers ran the molten slag into sand beds in front of the smelting units—as was the common practice—it made the building unendurably hot, wasted large amounts of space as it cooled, and proved expensive to carry out of the smelting house. To solve the problem Pearce fitted each furnace with slagging doors connected to iron troughs that carried the molten waste outside the building onto a dump. There it sizzled into a solid mass that Hill eventually sold to railroad companies for ballast on their lines.[49]

Pearce also evolved new methods for roasting ores before smelting. During the 1880s he replaced the old-fashioned calciners with Brown-Allen-O'Harra furnaces that had two hearths set one above the other. They eliminated the workmen who rabbled the ore charge, but despite the saving in labor the new roasters needed constant repair because hot sulfides damaged the moving parts. After enduring years of frustration and high maintenance costs, Pearce finally designed the prototype of what became known as the Pearce turret furnace. This was a significant improvement. Pearce and Crawford Hill sub-

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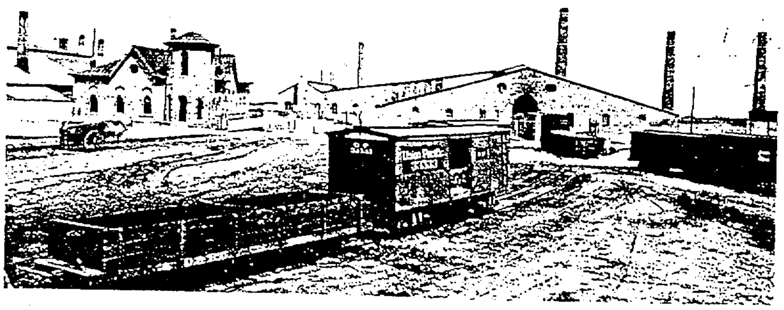
Pearce and Crawford Hill sub-

sequently organized a corporation to control the patent and sell units to silver-lead smelters, which also found the furnace useful. Later, Henry Williams and Richard Francis Pearce, the inventor's son, extended the design by adding tiers that reduced the consumption of fuel.[50]

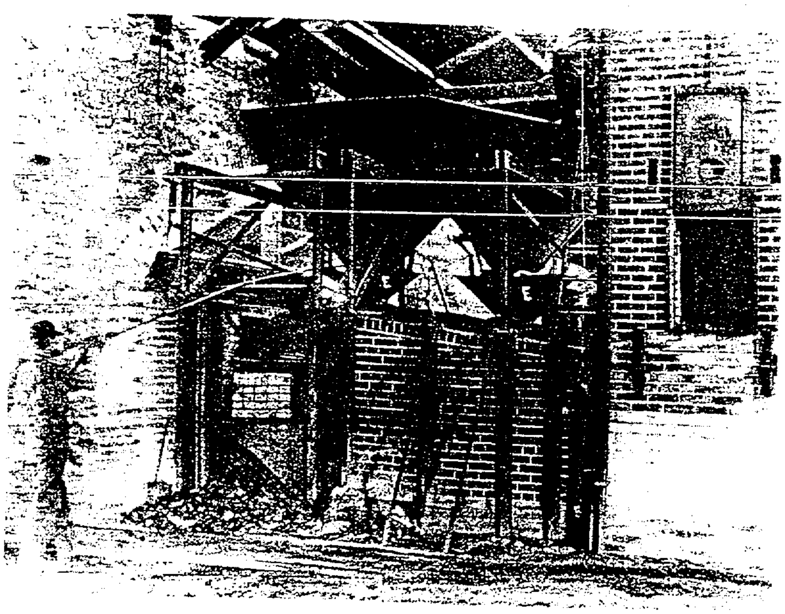
The culmination of Pearce's technological success came in 1888 when he was elected president of the American Institute of Mining Engineers. As the topic of his presidential address, he chose the Argo process and provided the most articulate discussion of the method since Thomas Egleston's article more than a decade before; yet for "certain business considerations" he could not elaborate on the supposedly secret process. He also alluded to the failure of so many small smelters and the rise of a few large companies working in the urban centers of the West—a case of "the survival of the fittest."

Pearce's achievements in technology, combined with declining expenditures for labor and transportation, enabled Hill and his associates to lower their reduction costs, which meant they could pass on some of the savings to mining companies. (Competition from the silver-lead processors also forced them to do this.) As the eighties slipped by, the firm increased its returns to shippers, until by 1889 the enterprise bought ores for about 85 percent of their gross value, a remarkable rise from the early seventies, when Hill's "pay" hovered around 30 percent.[51]

During these years newspapers and trade journals occasionally mentioned rumors that Hill and his colleagues intended to build other plants or enter new aspects of the reduction industry. As early as 1883 the *Mining and Scientific Press* reported that businessmen from Tucson in the Arizona Territory had approached Hill about building a smelter in the sunbaked desert community. The editors were of the opinion that the firm could "afford to spare millions without any embarrassment whatever." Four years later, in November 1887, the editors of the *Engineering and Mining Journal* relayed speculation that the smelting company was about to erect blast furnaces and move into the silver-lead business, ostensibly because Hill, Pearce, and Wolcott had invested in certain mining properties. About a year after that, others claimed Hill was about to aban-



The Argo smelter about 1900. William H. Jackson, photographer. Colorado Historical Society, Denver.



Charging a furnace at the Argo smelter. Jesse D. Hale, photographer. Colorado Historical Society, Denver.

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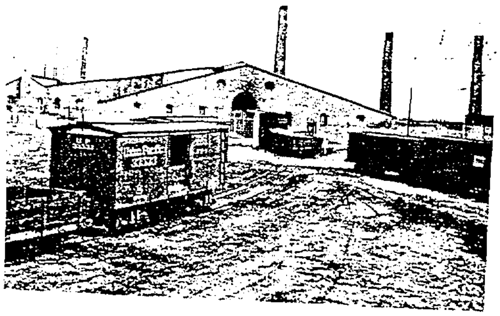

1900. William H. Jackson, photographer.
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·go smelter. Jesse D. Hale, photographer.
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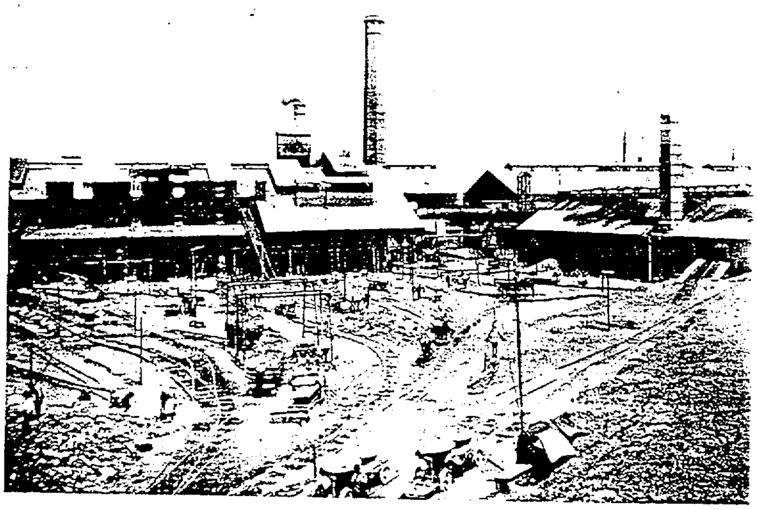
don his plant at Argo and relocate in Trinidad because the town had made an attractive offer that included very inexpensive supplies of coal. Finally, in 1889 another story intimated that Hill and his associates would erect a silver-lead smelter in Roaring Fork Valley. This plant would process low grades of ore unable to bear the cost of transport from the mines of Aspen to the furnaces of Leadville, Denver, and Pueblo. The men of Argo did none of these things, however, even if they considered such ventures seriously. Many years later Hill's brother-in-law, Jesse D. Hale, who held several managerial posts at Argo, wrote that management was very conservative and in particular did not wish to enter the highly competitive lead reduction industry.[52]

As the nineties dawned, Hill and Pearce continued to draw the bulk of their ore supplies from markets in Colorado. Mining companies on the forks of Clear Creek, the traditional source of mineral, sent carloads of pyrites via the Colorado Central Railroad down the narrow canyon to the Argo furnaces. And as the years passed Hill and Pearce competed effectively for the rising output of dry ores shipped from Leadville, Aspen, and other mining camps in the central Rockies. When Cripple Creek burst into its bonanza days as a fabulous producer of gold, Hill and Pearce found another lucrative source of mineral very close to Denver.

Yet, as they had done since the last years at Black Hawk in the 1870s, Hill and his colleagues still drew ores and matte from distant mining districts. They signed contracts with companies working veins and stopes in Idaho, Utah, Nevada, New Mexico, Arizona, and Mexico. Unlike their rivals in the silver-lead business, Hill and his associates never had to rely on the production of either Idaho or Mexico for the base metal essential in reduction. Yet this was small comfort. As the years passed, the Argo works grew ever more dependent upon the mines and smelters of Butte, Montana, for copper essential in what had become known as the Argo process. Hill and Pearce bought large quantities of both matte and silver-copper ores from the district, much of it coming from Williams's Colorado Smelting and Mining Company or the mines of William Andrews



The Globe smelter about 1900. William H. Jackson, photographer. Colorado Historical Society, Denver.

Clark. Hill also purchased some supplies of matte from silver-lead smelters who formed it as a by-product in reducing copper-bearing ores.[53]

Even though Hill and Pearce searched far outside Colorado for ores and matte, the value of metal shipped by the Argo smelter reached a plateau during the eighties. After rising steadily from the $271,000 worth of matte sent to Wales in 1868, the output touched $4,400,000 in 1884, a notable achievement; but, after that, shipments from Clear Creek and Gilpin counties fell off and the smelter's production slipped to $3,700,000 by 1886. From this point Hill and Pearce increased their output, but they failed to surpass the high of 1884 until 1890, when they marketed silver, gold, and copper worth $5,000,000. Production then rose for two more years, reaching an all-time peak of $6,060,000 in 1892.[54]

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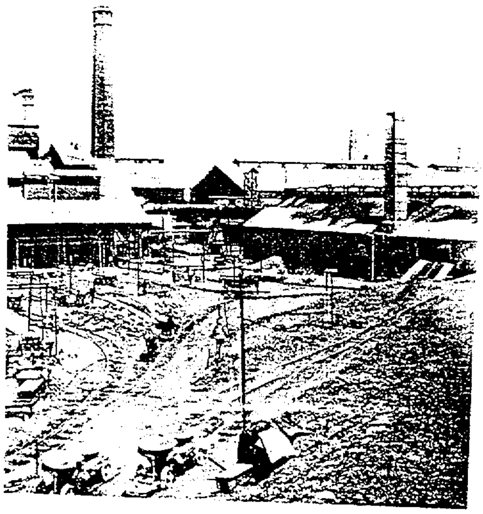

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Eddy, James, and Grant; Holden, Sheedy, and Iles were familiar in mining camps from Canada to Mexico and from Colorado to California. They had built large plants, tapped distant ore markets, and carried the art and science of ore reduction to its most advanced degree. Yet, even as they transformed Denver into the great reduction center of the high plains, other smeltermen looked to Pueblo, a hot, dusty community that envisioned itself as "the Pittsburgh of the West."

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Chapter 9

Reduction in the Age of ASARCO

ONCE THEY TOOK CONTROL OF ASARCO, EDWARD W. NASH AND his colleagues turned their attention to centralizing operations and coordinating their far-flung network of smelters and refineries. To facilitate the work, they delegated responsibility to various groups. August R. Meyer headed the new ore-purchasing committee, James B. Grant the operating committee, and so on.[1]

Rather than move to New York, where the firm established its corporate offices, Grant began rationalizing operations from his old headquarters in Denver. And perhaps this was a logical choice, since about half of ASARCO's plants were in Colorado. Once in charge, Grant and his lieutenants outlined uniform assaying procedures, standardized ore-purchasing policies, and apportioned shipments to various smelters. Soon it became common for Grant's traffic directors to have large shippers like the Ibex Mining Company of Leadville send consignments to four or five different plants. Such practices enabled ASARCO to carry lower stocks of mineral, yet gave metallurgists greater flexibility in preparing reduction charges. The arrangement also freed working capital that the enterprise needed. Yet Grant and his associates had barely commenced work when they found themselves confronted by a serious labor dispute, one that was to have unforeseen consequences for ASARCO.[2]

Shortly before the company's formation, the Colorado General Assembly had passed a bill giving workmen an eight-hour day, and Governor Charles S. Thomas had signed the measure into law, taking effect on June 15, 1899. The statute was in line with the national objectives of the labor movement, but the business community opposed it with the claim that it was unconstitutional for a state government to regulate hours of work. Yet this was little more than a smokescreen to hide the real issue. These men were simply opposed to organized labor, which had pushed the bill, and their opposition took on an emotional component because the law drew ardent support from the Western Federation of Miners, a union known throughout the West for its militant postures and quasi-socialist views.

The controversy surrounding the eight-hour statute set the stage for a major struggle between ASARCO and its employees. Like most business leaders in the state, particularly those in the minerals industry, Grant and his colleagues looked askance at both the eight hour law and organized labor. In particular, they opposed the Western Federation of Miners, whose subdivision, the Mill and Smelterworkers Union, was recruiting members in the company's plants.[3]

Somewhat surprisingly, the conflict began in the San Juan two weeks before the eight-hour bill became law. On the morning of June 1, Franklin Guiterman posted a notice outlining the firm's plan to pay workers on an hourly basis. The company would not require anyone to work more than the eight hours specified by the new statute, but each man would have that option. Once he had posted the notice, Guiterman left Durango on a business trip, but he gave instructions that only he could countermand the order. That afternoon a committee from the smelter workers' local told Guiterman's lieutenants that the union would go on strike the next day if they did not remove the notice. Guiterman's subordinates, however, either would not or could not alter his instructions. With the situation at an im-

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passe, 150 men, nearly the entire work force, walked off the job on June 2. Mines in the San Juan began to close.

During the next two weeks Grant tried to head off a general strike at the plants in Leadville, Denver, and Pueblo. He and his colleagues decided to offer their employees hourly pay plus a 10 percent increase in wages. This in effect would restore the pay scale prevailing in 1893—provided each man stayed on the job for twelve hours. The smelter workers rejected the offer. They wanted ASARCO to recognize the union, and they wanted to preserve the existing wage rates—but for eight hours' work. This was not unreasonable, for pay in the industry was low. Even so conservative a mining man as John F. Campion, no friend of labor, thought it would be impossible for a man to obtain the necessities of life if the enterprise reduced the wages of unskilled workers from the prevailing scale of $1.75 daily.[4]

Campion's views notwithstanding, the men of ASARCO refused to budge. They thought that any pay increase exceeding 10 percent would eliminate profits, and, in fairness to them, their enterprise was new, its future uncertain. But Grant and his associates were opposed in principle to unions, particularly so militant an organization as the Western Federation of Miners. For a whole week Grant encouraged discussions between his plant managers and the smelter workers, but the talks failed to break the impasse. When the eight-hour law took effect on June 15, a majority of the workmen at Leadville, Denver, and Pueblo took the furnaces out of blast, then walked out. The general strike was on.

The stoppage affected the entire region. The smelters announced they would purchase no more fuel and ore until the walkout came to an end, a pronouncement that prompted layoffs in the coalfields and hard-rock mines. One observer went so far as to predict that thirty thousand men would be out of work if the strike lasted more than thirty days. Union members elsewhere in Colorado set up picket lines to show support for the smelter workers, while other workmen struck here and there over the same issues.

But not all the smelters closed. In 1893 Nathaniel P. Hill and his associates had not reduced the wages of their employees, and now in 1899 they arranged a compromise on the eight-hour issue acceptable to their workmen. The Argo works remained in operation, its reverberatories running steadily throughout the summer. And in Pueblo Simon Guggenheim negotiated long hours with smelter workers at the Philadelphia plant as the fifteenth of June approached. Finally, on the evening of June 16 the two sides reached a compromise that called for increases in pay ranging from 25 to 40 percent, the highest raises going to the lowest-paid. Guggenheim telegraphed the details to the family offices in New York, then a tense period of waiting followed as his father and brothers considered the pact. After lengthy debate they decided to accept it. And so during the summer of 1899 the Guggenheims ran their plant at full capacity while the men of ASARCO fought what proved to be a long, hard strike.

Meanwhile, efforts developed to resolve the dispute between the "smelting trust" and its employees. When news of the Guggenheims' settlement appeared in the press, the smelter workers union offered to end the walkout if ASARCO would agree to a similar compromise. But Grant and his colleagues were unmoved by the suggestion. Then the State Federation of Labor offered to serve as mediator. In a letter to Grant the organization's executive board requested a conference with representatives of the smelting company not only on behalf of the strikers, but also in the interest of the railroad, mining, milling, and manufacturing industries who, said the board, found their prosperity menaced by the closing of ASARCO's plants. Grant replied that he was aware of the "gravity" of the situation, but he thought that the "economic condition of the mining and smelting industry" precluded any possibility of increasing wages beyond the current offer. He added that he was willing to discuss the question with his employees, but not with the federation, since it knew nothing of the reduction business.

Only two days after the strike began, Governor Thomas decided to intervene because the walkout posed a threat to the state's economy. On June 17 he appointed a citizens' committee to look into the dispute and recommend a solution. This group, which included former governor Alva Adams, met with repre-

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sentatives of both sides. Grant reiterated his original proposal of hourly pay with a 20 percent wage increase. The smelter workers countered with the Guggenheims' scale, which would have provided the strikers a raise greater than ASARCO's offer but lower than their original demand. The citizens' committee held several more meetings, but when neither side showed any willingness for further compromise the group dissolved, having achieved nothing.

As soon as it became obvious that this effort had failed—and it became obvious in a very short time—the union maneuvered to bring the State Board of Arbitration into the dispute. The General Assembly had created this agency in hope of preventing strikes and lockouts, and it consisted of three members appointed by Governor Thomas. On June 28, with the walkout nearly two weeks old, the smelter workers' local in Denver asked the board to intervene. The next day William F. Hynes, secretary of the organization, asked Grant to let the conflict be settled by binding arbitration. But Grant remained firm in his position. He replied that the company had no business relations with the union and that it would not deal with it. The enterprise intended "to exhaust all legitimate resources" in resolving the issues before it would resort to a compulsory settlement.

The Board of Arbitration then took more forceful action. It had the power to compel witnesses to attend its deliberations and give testimony. When ASARCO received a subpoena, Grant announced that the firm would comply, but he insisted that the enterprise would not be bound by the board's conclusions and would not recognize the union. The remarks of ASARCO's president, Edward W. Nash, were even more forceful. He was quoted as saying that the firm would rather close its doors than tolerate such an organization. He and his associates would run the business to suit themselves and would not accept the dictation of other parties.

The smelter workers adopted a more conciliatory attitude, for they had much to gain—and ASARCO much to lose—by the board's action. The board was at least moderately prolabor and, as in most arbitrations, was likely to choose a compromise position that would benefit the unionists. They immediately proposed to end the walkout if ASARCO would agree to be bound by the board's findings. But Grant and Nash rejected the offer. They realized that the committee was likely to find a middle ground that would mean an increase in wages beyond the standard offer and knew that the committee might also force them to recognize a subdivision of the Western Federation of Miners.

While maneuvering went on in Denver, the strike front began to crumble. The smelter workers at the Bi-Metallic plant in Leadville had not joined the union but had walked out in sympathy with their comrades elsewhere. In late June they decided to abandon the picket lines and return to work on the basis of ASARCO's standard offer, hourly pay and a 10 percent increase in wages for twelve hours' labor. By early July the smelting company had the first of its furnaces back in blast.

About two weeks later the unionists received a serious blow. On July 17, the supreme court of the state of Colorado declared the eight-hour law unconstitutional—just as the more conservative businessmen had contended from the outset. This decision cut the ground from under the men on the picket lines. The strike at the Arkansas Valley plant collapsed immediately, and by the end of the month its furnaces were back in blast. The Pueblo and Durango works followed quickly.

Yet the Denver smeltermen continued to hold out. In late July the Board of Arbitration met with both sides and submitted a report calling for a compromise. But the findings were not compulsory, and ASARCO, its position immeasurably strengthened by the supreme court's decision and the strike's collapse elsewhere, rejected the proposal. The unionists continued to man the picket lines around the Globe and Grant smelters, but with their resources nearly exhausted the smelter workers could not remain in strike much longer. Two more weeks passed. Then on August 13 the strikers agreed to accept the firm's offer and declared the walkout over. By the end of the month ASARCO had put its Globe and Grant smelters back in operation.

Nash and Grant and their associates had defeated the unionists, but it was a Pyrrhic victory. The strike had disrupted

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the firm's cash flow and eliminated about $380,000 in revenues, according to one estimate. Nash and his colleagues could ill afford so large a loss so soon after the company's formation. Equally bad, management had wasted its time and energy in combating a walkout instead of concentrating its efforts on reorganizing the firm's internal structure. In retrospect, however, it is hard to see how the men of ASARCO could have reacted differently given their views on the eight-hour law, their conviction that the enterprise would be doomed if they made concessions, and their unyielding opposition to the Western Federation of Miners. Nonetheless, the bitter strike of 1899 was only a harbinger of turbulent labor-management confrontations that would beleaguer the firm in the years to come.[5]

Once operations resumed, the leaders of ASARCO gave their full attention to forging a smooth-running industrial empire out of the disparate parts they controlled. This objective required the firm to close many plants, for the business had excess capacity, as the smeltermen had long claimed. Nash and his colleagues began dismantling seven complexes during the first eight months of the firm's life, and the wrecker's victims included the Hanauer and Ibex smelters in the Salt Lake Valley, two plants in the Chicago area, the Pittsburgh and El Carmen works, and the long-idle American smelter in Leadville. The next year Nash and his colleagues closed both the Union and the Bi-Metallic plants in order to consolidate their Leadville operations at the Arkansas Valley works. Nine plants gone in scarcely one year! Yet all was not destruction. The firm had Karl Eilers build a large, integrated smelter at Murray, Utah.[6]

ASARCO ended its turbulent first year with a profit of $3,500,000, a relatively small return on a nominal capitalization of $65,000,000. It enabled the company to pay three dividends amounting to $1,500,000 on the preferred stock, but the holders of common stock received nothing because the firm needed the rest for plant improvements and working capital. Yet even this proved inadequate. ASARCO needed new capital, a need that pushed Nash and his associates toward other mergers. On March 20, 1900, the directors authorized the officers to ascertain the terms and conditions by which the enterprise might acquire its two principal competitors, Robert S. Towne's Compania Metallurgica Mexicana and the firm of M. Guggenheim's Sons, both thought to be rich in cash.[7]

By 1900 Towne had converted "the metallurgical company" into the largest integrated mining and smelting firm in Mexico. Using capital from Boston, New York, and Europe, he had acquired mines, erected a huge smelter at San Luis Potosí, and developed several ancillary firms, most notably the Mexican Northern Railroad. Many thought that Towne's company had a strong cash position, but actually the collapse of silver had destroyed Towne's prospects, forcing him to sell bonds to pay the dividends required on the preferred and guaranteed stock. Many shareholders were disappointed that Towne had not sold his controlling interest to the syndicate that created ASARCO.

How much Nash and his associates knew about the internal affairs of the CMM is not certain , but they must have known a great deal, for Towne and August R. Meyer were directors of both firms. Nonetheless, James B. Grant visited the mines and works of the company and examined its books. Then he sent his report to Nash. As might have been expected, Grant advised against acquiring the enterprise. His line of reason never appeared in public, but it seems likely that he must have noted the large debt and other obligations. Towne's company would only add to ASARCO's burdens. And there the matter ended.[8]

Meanwhile, what about the Guggenheims? They had not sold the firm of M. Guggenheim's Sons to the syndicate that created the "smelting trust," although they had participated in the merger talks. During the negotiations Moore and Schley had offered the family about $11,000,000 in the combine's stock in exchange for a reduction empire estimated to be worth $5,000,000 to $8,000,000. It has always been said that Meyer Guggenheim opposed the deal because he did not want to see the plants pass into the hands of an enterprise that he and his sons did not control. This may well be true, but one wonders. The Guggenheims had much more at stake in other quarters.[9]

Even as ASARCO came into being, the family was engaged in forming a new corporation. In February 1899 they obtained the support of a group of New York and London financiers that

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Simon Guggenheim about 1908, while a United States senator from Colorado. Like Nathaniel P. Hill and James B. Grant, he converted his success in business into success in politics. Colorado Historical Society, Denver.

included William C. and Harry Payne Whitney along with Sir Ernest Cassel, and together with them they launched the Guggenheim Exploration Company, sometimes known as

Guggenex. The family acquired only about 17 percent of the outstanding shares in this venture, but Daniel Guggenheim and his brothers directed nearly all operations. Over the next few years this firm acquired many mining properties in the United States and Mexico, and most of the ores produced went to the Guggenheim smelters.

The family also benefited from the strike that idled ASARCO's plants in the summer of 1899. When the passage of the eight-hour law created time and wage questions, Simon Guggenheim negotiated a settlement acceptable to labor and management. This was fortunate because it enabled the Philadelphia smelter at Pueblo to remain in blast while its rivals in Denver, Pueblo, and Leadville shut down. As a result, mining companies in Colorado overwhelmed the Philadelphia works, leaving Simon Guggenheim and his chief lieutenant Edgar L. Newhouse with their pick of the highest grades of ore at the most favorable smelting rates. By the end of this turbulent year the Guggenheims' empire in metal stood in excellent financial condition, and the family had ready access to the capital markets of New York.[10]

It was this strong position that prompted talks between the Guggenheims and ASARCO. Negotiations began in the summer of 1900, scarcely a year after the original merger, and in the fall Nash and his associates offered the family a lucrative package. They would increase ASARCO's nominal capitalization from $65,000,000 to $100,000,000 then give the Guggenheims $35,000,000 worth of this stock—half in common, half in preferred—in return for all the plants of M. Guggenheim's Sons, "good will," and $7,500,000 in cash or its equivalent. Yet this offer was not quite so breathtaking in reality as it appeared on paper, and the Guggenheims knew it. The market price of ASARCO's stock was far below the nominal par value of $100 per share, and the family had to provide $7,500,000 in cash. Still, the "smelting trust" had tendered far more than Moore and Schley in 1899. But the Guggenheims were in no hurry. They demurred, and talks were broken off until after the national elections that November.

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reelected, the Guggenheims and the management of the American Smelting and Refining Company resumed negotiations. In January 1901 they reached a tentative agreement calling for ASARCO to increase its capitalization from $65,000,000 to $100,000,000—half in preferred stock and half in common. Of this the Guggenheims would receive the $35,000,000 in new securities plus the $10,000,000 in stock remaining in the treasury from the time of the original merger two years before. In return ASARCO would obtain the four plants belonging to the firm of M. Guggenheim's Sons plus $6,000,000 in cash and another sum equal to two-thirds of ASARCO's working capital as of January 1, 1901, a figure agreed upon as $6,067,000. Yet the Guggenheims did not have $12,067,000; so in the settlement Henry H. Rogers offered to provide them with $6,000,000 in cash in return for the $10,000,000 worth of stock in ASARCO's treasury. The merger now lay in the offing. The first public indication of what was about to happen appeared on January 19, 1901, when the directors of ASARCO called for a special meeting of the stockholders to be held on February 16 to consider the acquisition of M. Guggenheim's Sons.

Now came the complications. After the union, Nash and his colleagues intended to market copper through the Guggenheims' selling agency, which ASARCO would acquire in the merger. This was a logical decision but it was not acceptable to Rogers and Lewisohn. They wanted to continue handling the product through their firm, the United Metals Selling Company—which was the reason they had financed the original combination. When the Guggenheims and ASARCO's management, now acting in concert, insisted upon using the family agency, Rogers and Lewisohn resigned from the board of directors. On February 15, the day before the stockholders were to vote, Rogers and Lewisohn had their lieutenants obtain a temporary injunction forbidding the merger on the grounds that it would produce a monopoly in restraint of trade. A day later the judge modified his ruling to permit the shareholders to vote on the proposed consolidation on the condition that should it be approved—and it was—the union should not go into effect until the New Jersey courts should try the case.

During the next two months the adversaries maneuvered on two levels. They contested the injunction publicly in the New Jersey courts, although the question of monopoly in no way resembled the real issue. At the same time Daniel Guggenheim, Nash, and their colleagues quietly negotiated with Rogers and Lewisohn. In the midst of these deliberations a lower court denied the injunction on March 2, but Rogers and Lewisohn had their lieutenants appeal the decision.

The climax to the struggle came on the afternoon of April 18. Guggenheim, Rogers, and their associates resumed the clandestine talks at the law offices of Samuel Untermeyer, who handled much of the Guggenheims' legal work. Both sides were approaching an agreement, and discussions continued into the evening at Delmonico's, a posh restaurant in New York. There the two groups resolved their differences. The men of ASARCO agreed to grant the United Metals company a five-year contract for the sale of copper. This arrangement would be more expensive than selling through the Guggenhims' agency, but at least the smelting enterprise would receive a greater return than before. Rogers received from the Guggenheims $10,000,000 in ASARCO's stock and provided them with the $6,000,000 they needed to complete their obligations. Rogers and Lewisohn then withdrew the suit, but by then it no longer mattered, for the New Jersey courts had denied the appeal earlier in the day. On the night of April 18 ASARCO's representatives filed the appropriate papers in the state capitol at Trenton.[11]

Once the stock transfers had been completed, the Guggenheims took control of the enterprise. Daniel was elected chairman of the board of directors and chairman of the executive committee. He would be chief architect of the firm's destiny for the next two decades. His brothers Simon, Morris, Isaac, and Solomon also took seats in the directorate. Nash remained president, but overnight he found his role diminished. Isaac replaced Winthrop E. Dwight as treasurer, and Solomon superseded August R. Meyer as chief of the ore purchasing committee. Meyer retained his seat in the directorate, but as time passed he had less and less to do with entrepreneurial affairs. James B. Grant and Anton Eilers held their positions.[12]

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Under the leadership of Daniel Guggenheim, the American Smelting and Refining Company continued the reorganization launched by Nash and his associates. To coordinate all operations in the Rocky Mountain region, Guggenheim had the firm establish a Western Executive Committee, initially headed by Grant. When he had a heart attack in 1902, the enterprise reformed this loose organization into individual departments. Franklin Guiterman emerged as general manager of the Colorado Department and became the firm's chief operative in the Rocky Mountains.[13]

During this time zinc assumed a far more important role than previously. For decades the smelters had penalized ores holding even small quantities of the metal because it interfered with the formation of silver-lead bullion. In the late nineties, however, the price of zinc had risen sharply because of an increase in demand and the efforts of producers in Missouri to restrict their output. The situation had prompted O. E. Jacobson & Company of New York to ship small consignments of ore from the high country via Galveston, Texas, to a smelter at Nurpelt, Belgium. As the experiment returned a profit, the Jacobson enterprise began shipping large quantities of mineral drawn from the shafts and stopes of the A. Y., Minnie, Maid of Erin, Iron Silver, and other mines at Leadville. This situation resembled the one prevailing in the minerals industry many years before, and of course it was not to last.[14]

The Guggenheims, who still owned the A. Y. and Minnie mines, saw the potential for profit in treating zinc ores in the United States. In June 1901, shortly after they merged their interests with the "smelting trust," the major figures in the combine formed a subsidiary corporation, the United States Zinc Company, setting the capitalization at $1,000,000. ASARCO acquired the controlling interest and later bought all the outstanding stock. Daniel Guggenheim was elected the first president but later gave way to Nash. Grant became agent in Colorado, but after his heart attack he turned his responsibilities over to Guiterman.[15]

It took Guggenheim, Nash, and Grant another two years to get their projected plant on stream. Knowing that ore supplies would come primarily from Leadville, they decided to erect the works outside Pueblo and integrate operations with their three smelters in town. Then for technology. Because no one employed by ASARCO had much, if any, experience with the methods to be used, Guggenheim and his associates looked to Europe for the metallurgists who would install what was known as the Belgian retort process. In the fall of 1901 Joseph Schulte and K. Suhlberg arrived in Pueblo to duplicate the technology used at Nurpelt, Belgium. Simon Guggenheim later claimed that the plant was "largely in the nature of an experiment"; but in fact the United States firm chose proved equipment, installed and run by experts.[16]

Not until June 8, 1903, did the company open its works at Blende, a new town that took its name from a characteristic zinc ore. The plant had a capacity of sixty tons daily and produced a compound known as spelter, which averaged about 88 percent zinc. This the plant shipped east for marketing. The residue consisted of another product about 10 percent lead and 3 to 5 percent zinc that was sent primarily to the Eilers smelter for further working.[17]

Once it was in operation, Nash and his associates kept the Blende plant running steadily. The zinc production of mines in the high country rose sharply during these years, and Leadville took the lead. Properties like the A. Y., Minnie, Ibex, and Yak put out new riches. Nash and his colleagues expanded their capacity to keep pace with production, but despite their efforts they could process only a small portion of the output because of strong rivals in Colorado, Kansas, and Missouri. Nonetheless, the production of spelter rose steadily until 1907, when a financial crisis precipitated a sharp decline in zinc prices and forced many shippers to close. Nash and his associates cut wages in an effort to maintain profit margins. Two years later this prompted a strike as the employees walked out in hope of regaining the old wage scale.

The United States Zinc Company provided a small but significant addition to ASARCO's business. The metal gave the parent firm another product to market, and the plant increased the lead supplies of the Pueblo smelters, which always needed the

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base metal to collect silver. Yet the works also augmented ASARCO's drive for integration, since the bulk of the ore supplies came from mines controlled by the Western Mining Company, another subsidiary of the "smelting trust." The activities of the United States enterprise represented another American effort to draw upon the technology of Europe—an old theme, to be sure, but one that was to continue well into the twentieth century.[18]

As the Blende plant came into being, the men of ASARCO continued to integrate operations by forming another enterprise—the Carbon Coal & Coke Company. The chief responsibility fell to Franklin Guiterman, then emerging as ASARCO's chief manager in Colorado. Under his direction Carbon Coal & Coke acquired a large mineral deposit in a place known as Reilly Canyon, about seven miles southwest of Trinidad in the Spanish Peaks region. Guiterman opened the mines, erected a washery, and built a coking plant that eventually consisted of 350 beehive ovens. To guarantee the works a steady supply of labor, Guiterman had the firm construct a company town known as Cokedale, which had 1,300 inhabitants by 1909.[19]

Meanwhile, the Guggenheims and their associates continued to streamline their main operations by phasing out obsolescent or unneeded smelters and refineries. In 1901 the enterprise closed the Great Falls, Mingo, and Argentine plants in the United States and the small Antofogasta works in Chile. The next year the firm shut down the Germania and Philadelphia smelters, although the latter continued working small quantities of copper minerals until 1905, three years after its last shipment of silver-lead bullion. Yet Karl Eilers finally opened a large, integrated smelter at Murray, Utah, and this plant took possession of the ore shipments that had previously gone to the old plants in the Salt Lake Valley.[20]

By the end of 1901, ASARCO virtually controlled the market for Colorado's production of smelting ores. The Argo works and a few other firms offered a measure of competition for certain classes of mineral, but these enterprises had relatively small capacities in comparison with their giant rival. ASARCO's managers regulated the output of the mines and sometimes increased reduction charges, which contributed to more friction between miners and smelters. Throughout the high country, many mineowners and managers deplored the company's preeminence and called for new smelter construction to combat the inequities of the "trust." Others wanted the federal government to "bust" the combine, which one man claims was "crushing the life out of the mining industry"—as he wrote President Theodore Roosevelt.[21]

Yet no one deplored ASARCO's position when the firm raised its ore prices. Early in 1903 the enterprise passed on to mining companies a general advance in the price of lead. This stimulated production from marginal properties at Leadville, Aspen, Silverton, and other camps and provided greater profits for the large shippers who were the mainstay of the corporation. But changes in the ore schedules were hardly altruistic.The enterprise controlled about 80 percent of American lead production, and fluctuations in the pay to mining companies tended to reflect the firm's desire to stabilize prices.[22]

But if mineowners were pleased by this turn of events, labor was not. Smelter workers still wanted higher pay, shorter hours, and better working conditions, and in 1903 these objectives precipitated another imbroglio between ASARCO and its employees. This time the trouble was confined to Denver. The preliminaries began on the first of May when the mill and smelter workers' union voted to demand an eight-hour day at the Globe and Grant works, but no one expected ASARCO to accede without a struggle. To increase their negotiating strength, union leaders spent the next six weeks recruiting new members and preparing for an almost inevitable strike. Then on June 17 a committee of the local politely opened the issue by sending a letter to Franklin Guiterman, now head of the Colorado department, headquartered in Denver. They requested that the firm grant all its employees an eight-hour day on the grounds that other smelter workers had it and that furnace work was both hazardous and unhealthful. They asked the firm to comply by July 1.

Guiterman was out of town on business when the letter arrived at his offices, and nearly two weeks passed before he replied. In a

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note to the local, he emphasized that ASARCO did not recognize a union—which was the standard position of the firm. Then he took up the question of the eight-hour day. He pointed out that three-quarters of Colorado's smelting ores came from just three camps—Leadville, Aspen, and Creede—but since 1900 their gross tonnage had fallen 20 percent, coupled with another 15 percent decline in silver content. Adding to these problems, said Guiterman, was a decrease in the value of silver itself. To operate under such conditions and prevent mines from closing, the management had found it necessary to lower reduction costs and smelting fees through close working and better mineral distribution. In light of this, he had to deny the union's request on the grounds that an eight-hour day would increase smelting costs, these would have to be passed along to mining companies, and thus many firms would have to cease production.

With Guiterman's denial, polite exchanges gave way to militant action, as both sides revealed their hard attitude. On the evening of July 3, union members gathered at the Elyria town hall and voted overwhelmingly to strike the Grant and Globe smelters. Shortly after the meeting, a small group of men, perhaps twelve to twenty, marched to the Grant works. There they induced two hundred workers on the night shift to join the walkout. In an orderly fashion the fires were drawn and the electric lights turned off, although it has always remained unclear whether someone used the master switch or simply cut the cable. What workers, if any, wanted to remain on the job had to leave because of darkness.

From the Grant works the strikers headed toward the Globe smelter, but now, according to published accounts, they degenerated into an uncontrolled mob. As they reached the Globe plant, they encountered a wire fence, but this proved a small deterrent. The unionists stormed the gates, broke through, and entered the smelter, where they convinced the night shift to join the walkout. Most workers did so because they belonged to the local, but several who wished to remain on the job were beaten up. As the men left the plant, the night superintendent and some clerical workers managed to draw metal from two furnaces, but that was all. Three others "froze up."

Violence played little part in the rest of the strike, but it had already destroyed the union's public image, costing the workers dearly. Throughout Colorado the press denounced such outbursts as intolerable and directed strong criticism at the local. Equally bad, the violence reinforced the smelter owners' view that war prevailed between the company and the union. There could be no compromise. Grant himself declared that he and his colleagues were "in the fight and will be there at the finish. What is the use of giving in?"

Both sides then maneuvered for advantage, but ASARCO had the upper hand. The walkout idled 775 men, a good portion of whom set up picket lines around the Grant and Globe plants. On July 7, four days after the strike began, Guiterman obtained an injunction that prohibited picketing by the Mill and Smelterworkers local as well as by the parent Western Federation of Miners, the American Labor Union, the Denver Trades and Labor Assembly, and the Colorado State Federation of Labor. This injunction also accused the union officers of conspiring to thwart operations of the smelters. Simultaneously, Denver's ultraconservative, antiunion Citizens' Protective Alliance offered to help prosecute "lawbreakers"—meaning strikers—and recruit nonunion workers.

Maneuvering extended far beyond Denver. Even though the firm had closed several of its Colorado smelters, it still had excess capacity. To outflank the strikers, traffic directors diverted ore shipments destined for Denver to plants in Leadville, Pueblo, and Durango. Once the unionists realized that the continued operation of these smelters jeopardized the strike, they dispatched representatives to persuade fellow workers to join the stoppage. But ASARCO's managers countered this move by convincing other employees to remain on the job and abide by the decision reached in Denver. Citizens' alliances also harassed union organizers and drove them out of town. The Western Federation of Miners managed to stage a sympathy strike in Cripple Creek, and two-thirds of the work force temporarily shut down the Durango smelter, but these events had little influence on the situation in Denver.

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tense summer months. Two weeks after the walkout began, he reopened the Globe works with twenty-five nonunion men protected by the Denver police. Later he tried to import strikebreakers, an effort that failed. Then came a draconian move. The firm announced that it had decided to close the Grant smelter permanently in conjunction with its desire to streamline operations and phase out obsolescent plants. This may have been true, but it struck a hard blow at the strikers, for in one swift stroke ASARCO had eliminated 475 jobs. The Globe works had only 300 positions.

Yet the strike continued. Summer gave way to fall, and fall dragged on into winter—a long time to be out of work—and time was on ASARCO's side. As the unionists exhausted their resources, some reapplied for jobs. By November Guiterman had four smelting units back in blast at the Globe plant. Operations soon returned to normal, and the walkout withered away. Only bitterness remained.[23]

By the end of 1903 the American Smelting and Refining Company had sharply altered the complexion of the reduction industry in Colorado. The firm had consolidated its operations at the Arkansas Valley, Eilers, Pueblo, Globe, and Durango works. Gone from the business in the span of four years were the Grant, Philadelphia, and Bi-Metallic plants that had been important in western ore reduction for nearly two decades. ASARCO had only two rivals of any consequence: the old Boston and Colorado Smelting Company and the new Ohio and Colorado Smelting Company.

Yet even now ASARCO's ore buyers could not find enough mineral to keep all the furnaces in blast. The firm offered to pass at least a portion of its lower reduction costs on to mining enterprises, but this failed to stimulate production. The state's output remained high, but the shipments of relatively high-grade ores able to pay the cost of transportation and reduction by the smelting process were on the decline. Newer technologies like ore flotation and cyanidation were coming into their own as the best ways for treating low-grade mineral. These trends became ever more pronounced in the next few years.[24]

Meanwhile, as the Colorado department consolidated operations, contended with labor unions, and tried to increase ore production, ASARCO received a threat to its prosperity, if not survival, from another quarter. Early in 1903 Charles Sweeny, a controversial promoter, mineowner, and entrepreneur in the Coeur d'Alene, conceived the idea of uniting the major mining companies of northern Idaho into a single enterprise. Such a combination had much to recommend it, for this hypothetical corporation might deal firmly with the truculent Western Federation of Miners and might negotiate a far more lucrative reduction contract with the American Smelting and Refining Company. Sweeny did not have enough money to undertake such a venture, but he thought the man who did was John D. Rockefeller, the best-known businessman in America. Not only did the oil magnate have what seemed to Sweeny unlimited financial resources, but, more important, everyone in the Northwest knew that Rockefeller had invested heavily in the minerals industry. Sweeny logically assumed that he might be interested in the scheme.[25]

Early in 1903 Sweeny traveled to New York. He had hopes of persuading Rockefeller to finance the combination, but he was never to see him. Instead, it took Sweeny about two weeks to obtain an appointment with Frederick T. Gates, Rockefeller's lieutenant in charge of all investments in the Pacific Northwest; and it was to Gates, a Baptist minister turned businessman, that Sweeny outlined his plan. Gates found the scheme attractive, and so did John D. Rockefeller, Jr., who was taking over many of his father's business interests. After talks with the persuasive Sweeny, they recommended that Rockefeller finance the combination.

But John D. Rockefeller was opposed, and for good reason. In the early 1890s the investment banking house of Colby, Hoyt & Company had persuaded him to purchase large blocks of stock in several mining companies owning claims at Monte Cristo, Washington. To integrate operations, Rockefeller had financed the construction of a concentrator in the mining town, a railroad from there to tidewater, and a smelter outside the city of Everett. Unfortunately, the mining engineer who assessed the Monte Cristo properties had made an egregious error. The veins

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pinched out a short distance below the surface, and the mines proved nearly worthless. Nothing except red ink flowed into the Rockefeller offices in New York. By the time Sweeny appeared in 1903, Rockefeller had written off more than $850,000 in losses. He was understandably reluctant when his son and Gates relayed the details of Sweeny's plan, which called for the investment of several million dollars.[26]

Despite this reluctance, Gates and the younger Rockefeller were convinced that Sweeny's design would solve the problems in Washington. The Coeur d'Alene mines were great producers, their ores might make the Everett smelter profitable for the first time, and at the least the proposed corporation would take over the smelter, the concentrator, and the dreadful mines at Monte Cristo. At last Gates and the younger Rockefeller persuaded the oil magnate to finance the combination, but only on condition that other prominent businessmen would invest as well, the most prominent of these being George J. Gould, who controlled the Rio Grande Railroad and who would be expected to give the new enterprise favorable freight rates. Gould consented.[27]

Once the senior Rockefeller gave his reluctant assent, events moved forward. Supplementing his own network of connections with capital from Rockefeller, Sweeny purchased options on the Standard, Mammoth, and Empire State–Idaho mining companies. Simultaneously, Gates and the younger Rockefeller organized the Federal Mining and Smelting Company. On July 24, 1903, this firm obtained a perpetual charter from the state of Delaware. Preparations continued over the summer, then in September Federal took possession of every important mine in the Coeur d'Alene except the famous Bunker Hill & Sullivan. Sweeny emerged as president of the combine, but the real control lay in the hands of the Rockefeller group.

Daniel Guggenheim and his associates at ASARCO viewed the formation of Federal as ominous. They realized that by controlling more than half the known reserves of Idaho, Federal could demand a far more lucrative smelting contract than could its predecessors. Yet this was the least of their worries. Far more unnerving was the sudden appearance of rumors that Sweeny and the Rockefellers were about to enter the reduction industry on a grand scale. This was a virtual death threat to ASARCO, because its plants in Colorado, Utah, and other states depended to a great extent upon the Coeur d'Alene for lead essential in smelting dry ores. Federal's smelter at Everett was a rival of little consequence—small, isolated, undercapitalized—but if Sweeny and his financial supporters integrated their operations forward into ore reduction, as was suggested by the firm's name, ASARCO might well be doomed. And Nash, Grant, Eilers, and the Guggenheims all knew it.[28]

In this portentous situation Daniel Guggenheim and his associates had to deal with the Rockefeller group—or so they thought. During the summer Guggenheim and other corporate officials had "accidentally" met Sweeny on the streets of New York to sound out his intentions. Yet these men were no fools. They perceived that the real power lay in the hands of Gates and the younger Rockefeller. Daniel Guggenheim arranged a series of appointments with Rockefeller's son. The truth was that John D. Rockefeller had no intention of entering the reduction industry; in fact, he had consented to support Federal largely to create a vehicle with which to extricate himself from a business in which he had lost hundreds of thousands of dollars. But the men of ASARCO could not know this. John D. Rockefeller, Jr., drove a hard bargain. He and Guggenheim negotiated a five-year contract by which ASARCO granted Federal a lucrative smelting rate, placed no restrictions on production, routed the ores over railroads controlled by Gould, and leased the Everett works, which the "trust" soon purchased outright under the terms of the agreement. In return, the Guggenheims bound themselves not to purchase any mines in the Coeur d'Alene—meaning the Bunker Hill & Sullivan—for another two years.[29]

This arrangement proved satisfactory for a time. Sweeny shipped huge tonnages of mineral, which provided ASARCO's smelters in Colorado, Utah, and elsewhere with the lead essential in working dry ores. Yet the situation continued to worry ASARCO because the Rockefellers might yet take Federal into the reduction industry. Rumors circulated to this effect, and Sweeny talked openly about plans to do so. Scarcely anyone

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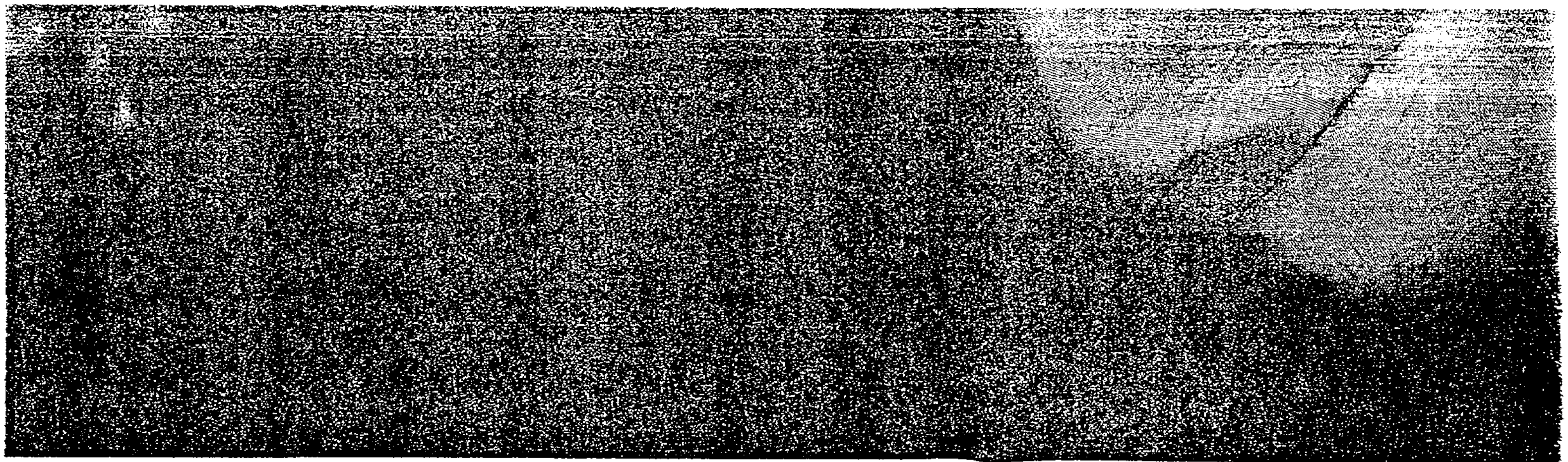
In light of the unconfirmed reports, Daniel Guggenheim once again initiated talks with John D. Rockefeller, Jr., this time with an eye to acquiring control of Federal. As the negotiations proceeded early in 1905, both parties began buying the company's common shares, which had been listed on the New York Stock Exchange. This competition, coupled with a general uptrend in the market, drove the price of Federal's common stock to new heights, but in the quest for control the Rockefellers had the advantage. By February 1905 they garnered an absolute majority. Then came the climax to the struggle. In a final round of talks with John D. Rockefeller, Jr., Daniel Guggenheim agreed to pay $120 a share, or about $3,300,000, for the nearly 27,500 shares held by the Rockefeller group. Yet Guggenheim did not have this much cash on hand; so in the final transaction the oil magnate decided to accept $1,300,000 in cash and lend the smelterman the remainder. On March 16, 1905, Charles Sweeny delivered 28,105 shares of Federal's common stock to Guggenheim in return for $3,372,600, of which Rockefeller received $2,200,600.[30]

ASARCO, however, did not take direct control of Federal. A short time before Daniel Guggenheim consummated the agreement with the Rockefellers, he and his associates organized a subsidiary corporation known as the American Smelters Exploration Company, which had a life span of only three weeks before it was reorganized as the American Smelters Securities Company. This enterprise took possession of Federal. Sweeny continued as president because the Guggenheims thought he was a good mining man, but as before the real control lay in New York—only now it resided in ASARCO's offices at 120 Broadway.

Once they took possession of Federal, the Guggenheims moved to assure ASARCO of complete supremacy in the Coeur d'Alene. This meant controlling the production of the Bunker Hill & Sullivan Company, the only major firm in northern Idaho beyond Federal's domain. After winding up his talks with the



Rockefellers, Daniel Guggenheim turned his skills in negotiation here, and soon ASARCO signed a twenty-five-year contract with the Bunker Hill & Sullivan, thus heading off potential competitors and insuring its smelters of adequate supplies of high-grade lead ores for years to come.[31]

Having secured their northern flank, Guggenheim and his associates used the Securities Company to extend ASARCO's control over the mining and smelting industries. Even as Daniel Guggenheim negotiated for the acquisition of Federal, he and his colleagues employed Bernard Baruch, then known as a shrewd Wall Street investor, to purchase the controlling interest in two other reduction firms, the Tacoma Smelting and Refining Company of Washington and the Selby Smelting and Lead Company of California. Not only did the Securities enterprise take over these corporations, it also purchased the majority interest in the Guggenheim Exploration Company, whose subsidiary, the Western Mining Company, controlled the Ute, Ulay, Auric, and Silver King mines in the San Juan country, the A. Y., Minnie, Adams, Maid of Erin, and Wolftone properties in Leadville, and even more valuable ore deposits in Mexico.[32]

During these turbulent years the old Arkansas Valley works deep in the Rocky Mountains, ten thousand feet above sea level, emerged as ASARCO's most important smelter in Colorado. Even before the Guggenheims brought their capital and expertise into the firm, Nash and the original management had increased the plant's ability to process the ever-lower grades of mineral coming from mines in the high country. Late in 1900 the company appropriated a sum estimated at $325,000 to install additional roasting and smelting units. The task of making the improvements fell to Julius Rodman, who replaced Joseph H. Weddle as manager about this time. When completed, the new furnaces gave the plant a capacity of about one thousand tons daily.[33]

Once the Guggenheims entered ASARCO, they kept the AV works running at full capacity, although there were changes in personnel and practices. Rodman's tenure at the smelter was short. When he left to assume a position with the Western Mining Company, the firm replaced him with William B.

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McDonald. Like his predecessor, McDonald proved resourceful in operating the plant, but like other smeltermen past and future he found himself unable to overcome dissatisfaction in the mining community, this time created when higher levels of management notified shippers in Leadville that in the future the smelter assays would prevail on all ore consignments unless there were huge discrepancies in determinations. In this case McDonald would send ore samples to Denver for the decision of an umpire. Some producers like the important Ibex Mining Company thought this arbitrary—a consequence of monopoly—and they ceased operation in protest. One mineowner complained that ASARCO's new system nearly always meant a judgment in the smelter's favor. Such protestations, however, were always temporary—no profits came from shuttered mines—and the AV works continued its steady reduction of a thousand tons daily despite the grumblings of the mining industry.[34]

Like these shutdowns, the bitter strike at the Denver smelters in 1903 had little real effect on McDonald's operations. Union representatives arrived in Leadville to persuade workers at the AV plant to join the walkout, but those efforts failed. McDonald kept the works operating at capacity throughout the dispute. Guiterman and the traffic managers rerouted some ore shipments to Leadville, and after a time this did create some aberration in McDonald's plans. By September, sulfide shipments had grown so heavy that ore cars choked the plant's railroad facilities, forcing McDonald to decline further consignments, which in turn compelled several mines to close.[35]

Even after smelting operations returned to normal, McDonald still had problems with excess sulfides. During the winter of 1904, he had to slow operations when silicious ores sent to be mixed with sulfides happened to freeze aboard railroad cars because of a labor scarcity that some attributed to the firm's low wages. A few months later an accident at the plant's power source compelled McDonald to curtail work at the sulfide mill. Soon the ore bins overflowed with fifteen thousand tons of mineral. McDonald asked the Ibex, Yak, Iron Silver, and other large producers to restrict their output, but they kept right on shipping according to contract. Then Guiterman took to his pen. He pointed out to one mineowner—John Campion of the Ibex—that such huge consignments were causing the AV works to incur "extraordinary expenses" that narrowed profit margins. Would the mine restrict its output? But Guiterman's pleas aroused no more sympathy than McDonald's. Men like Campion enjoyed ASARCO's plight and went right on shipping. To compound the problem, McDonald had to contend with a strike by wheelers and weighers who wanted an eight-hour day, but the walkout ended quickly with the twelve-hour shift intact.[36]

Soon the Guggenheims and their associates decided to increase the capacity of the AV works, a decision prompted largely by the rising production of low-grade sulfide ores in Leadville. In the fall of 1905 the firm appropriated enough capital for McDonald to erect two more blast furnaces and enlarge several others. Then came new technology. During the winter the men of ASARCO installed the Huntington-Heberlein process, another European development to which the enterprise had purchased the exclusive patent rights in the United States and Mexico. This method involved a form of blast roasting that lowered the cost of preparing sulfides for smelting. To make room for the new system, McDonald had to dismantle several old roasters. Output fell for a time, but by the spring of 1906 the works had a capacity of 1,400 tons daily, or about 500,000 tons yearly.[37]

These additions notwithstanding, McDonald still found himself deluged by sulfides. In spite of declining production here and there, Leadville and other mining camps sent huge tonnages to the Arkansas Valley works, and McDonald could never find enough silicious ores to mix with them in preparing furnaces charges. In May 1906 many employees left to find more lucrative work in Utah and Idaho, and ores piled up more rapidly than McDonald could have them smelted. This prompted Guiterman to write another round of letters asking ASARCO's "friends, the large shippers" to restrict their output because of the "frightful accumulation" of sulfides. Adding to this, he said, the railroads were hounding the firm to unload its ore cars. Yet the "friends" kept shipping according to contract,

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and the situation grew worse. By July nearly one-third of the work force had departed, and McDonald had to take several furnaces out of blast and run at three-quarters capacity.[38]

This situation continued into 1907. In January Guiterman reluctantly diverted some shipments to the Globe smelter in Denver, but the ores were so low in grade that they barely paid the freight tariff. This effort notwithstanding, McDonald still found himself unable to process the huge quantities of mineral shipped to the AV works for reduction. As a result the railroads charged the company $14,000 in penalty fees for failing to unload ore cars. When the difficulty persisted, Guiterman cut off the small shippers entirely, and several mines had to close because they had no other market than the Arkansas Valley smelter.[39]

Yet the problem of excess ores ended later that year. A new financial crisis that gripped the nation contributed to sharp declines in the prices of silver, lead, copper, and zinc. ASARCO met the situation by reducing its own returns on mineral, and many producers had to shut down because they could not operate profitably. Even when metal values rose two years later in 1909 and 1910, many potential shippers remained closed, particularly the smaller outfits that could not benefit from economies of scale in ore production. Leadville was at last on the wane as a mining camp, and after 1907 the Arkansas Valley smelter rarely worked at full capacity.[40]

The Globe plant, meanwhile, pursued a somewhat different course. After the long strike of 1903 it resumed operations as ASARCO's only smelter in the city of Denver. As before, it competed with the Argo smelter in the Clear Creek ore markets, drew other mineral from the central Rockies, tapped Cripple Creek for silicious ores, and reached across the continent for its remaining materials. And as before, it got its essential supplies of lead from mines in the Coeur d'Alene, a situation made easier once ASARCO took control of the Federal Mining and Smelting Company. By 1906 the Globe works, now under the management of Frederick Roeser, turned out 1,800 tons of bullion and another 200 tons of lead-copper matte monthly. And, what was more, the plant had the lowest smelting costs of any in

ASARCO's empire. These expenses became even less when the firm installed the Huntington-Heberlein process a few years later.

Yet, if smelting operations remained essentially the same, refining changed to a remarkable degree. The Globe had its own separating plant, the one built by Dennis Sheedy and Malvern W. Iles back in the early 1890s, but in the reorganization that followed the creation of ASARCO, Grant and his associates decided to phase out the refinery and send the bullion to Omaha for further working. The buildings remained, however, and after Guiterman became head of the Colorado department, he had new equipment installed so that the works could recover cadmium, thallium, and indium compounds captured in the bag houses used in all the firm's smelters.[41]

After 1907 the Guggenheims, Guiterman, and the other managers of ASARCO found themselves in an altered position vis-à-vis their Colorado smelters. The gross ore production of the high country remained steady, but the quantity of silver and lead in every ton declined sharply, as did the market value of the two metals. Over the next few years mining companies like the Ibex and Yak increased their output of complex zinc ores, keeping that industry alive and masking the decline of the more traditional elements. To process blende and other forms of zinc-bearing rock, rival enterprises erected plants in Oklahoma, Kansas, Texas, Illinois, and other states. All these works shipped large amounts of silver-copper-lead compounds back to ASARCO's smelters in Colorado for reduction, but the altered supplies of ore and new technologies for handling low-grade minerals changed the role of the smelting industry.[42]

In the years that followed the recession of 1907 and 1908, ASARCO's plants in Colorado rarely operated at capacity. The Globe smelter used about three or four of its seven blast furnaces, and the company lowered its wage scale in an effort to maintain profit margins. This led to short-lived strikes in 1910 and 1913 as the employees tried unsuccessfully to regain what they had lost. In Pueblo the enterprise closed the old Eilers plant in 1908, twenty-five years after the famous smelterman and his

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colleagues had broken ground. This left only the old works built by Mather and Geist in Pueblo, but in spite of the sharply decreased capacity the smelter rarely employed more than three or four of its smelting units. The Durango plant cut back to one furnace. The Arkansas Valley works maintained the largest capacity of any Colorado smelter, but rarely did the plant have more than five units in blast—half of those available. Even the high metals prices created by World War I failed to resuscitate the industry. Other firms with different technology received what benefits the conflict created.[43]

The Guggenheims and their associates could do little to prevent the collapse of ASARCO's ore markets. In July 1908 Guiterman wrote one mineowner that "for the first time in the smelting business I feel myself kind of groping in the dark." A year and a half later George E. Collins, another mining man, observed that one looked in vain for signs of prosperity, present or prospective, in the industry. He knew that ASARCO and its few remaining rivals needed new mining districts to provide additional supplies of ore, but he saw little chance of this happening. Prospecting was not energetic.[44]

As Denver saw its smelting industry collapse, the Chamber of Commerce appointed a special committee headed by Guiterman to investigate the decline and recommend measures to reverse the trend. In November 1910 he filed his report—not a propitious one. Not surprisingly, he reviewed the steady decreases in milling and smelting charges made over the years. Then he concluded with "disheartening disappointment" that lower reduction costs had not stemmed the decline of the mining business. Prospecting had nearly ceased, and, what was worse, the ore bodies that had sustained the minerals industry for decades were now virtually exhausted.[45]

By the onset of World War I nearly all the men who had guided the industry had passed from the scene. Malvern W. Iles had died in 1900; Edwin Harrison in 1902; August R. Meyer, Edward W. Nash, and Meyer Guggenheim in 1905; James B. Grant in 1911; and Benjamin Guggenheim in 1912. Edward R. Holden and Alfred W. Geist had vanished. Anton Eilers and

Franz Fohr had retired in the East, August H. Raht in San Francisco, and Otto H. Hahn in Germany, but they would all die before the guns of World War I grew silent. Only Daniel Guggenheim and his surviving brothers, members of a younger generation, remained. They controlled the remnant of ASARCO's Colorado empire from their offices in New York.

Chapter 10

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Chapter 10

"Groping in the Dark"

FRANKLIN GUITERMAN MAY HAVE VIEWED THE SMELTING industry with "disheartening disappointment" when he surveyed the field in 1910, but the same sentiments must have been felt in other quarters well before then. The early twentieth century brought even more challenging times to an already hard-pressed business. Yet the few remaining independents kept on working at least for a time, while new entrepreneurs still saw—or thought they saw—potential profits in reducing the lower and lower grades of ore coming from the high country mines.

In the early years of the century Crawford Hill became the chief architect in shaping the destiny of the Boston and Colorado Smelting Company, the state's oldest reduction firm. He had assumed an ever larger role in decision-making during his father's last illness, but he had never held an official position in the corporate structure. Once he took over full responsibility for western operations, he immediately sought to clarify his role in management. In letters to company officers in Boston he suggested that the board appoint him resident director, partly on the grounds that the firm was a Colorado corporation even though most of its stockholders lived in New England. This recommendation met with a favorable response, and the board named him to the position, much to Hill's satisfaction.[1]

Then came another question. Sometime during the nineties Nathaniel P. Hill had lent the corporation $275,000 for improvements to the Argo works. He had not insisted upon a formal schedule for repayment of principal and interest, largely because he had known the officers and directors for many years. Convinced of their friendship and integrity, he had been content to accept checks in varying amounts from time to time.

This arrangement, however, was not acceptable to Crawford Hill. He saw the president, Costello Converse, and other corporate officials in Boston primarily as business associates, not as friends of long standing. Thus he wanted the enterprise to establish a specific timetable by which it would repay this large debt to the family, and to this end he wrote George D. Edmands, the treasurer, that the Hills wanted quarterly interest paid on the outstanding notes. The question of money proved harder to resolve than the question of resident director, but after a year of proposals and counterproposals the Boston and Colorado firm agreed to exchange the Hills' outstanding notes for a new issue that carried annual interest of 4 percent paid quarterly.[2]

The death of Nathaniel P. Hill was a significant hour in the venture's evolution, but another of equal importance came in July 1901 when Richard Pearce resigned as manager of the Argo works. After nearly thirty years in the company's service this had been a hard choice, and Crawford Hill found the Cornishman "very unsettled" over his decision to terminate so long an association. Yet Pearce was now in his sixty-third year, the prospects of the firm appeared cloudy, and he may well have seen 1901 as a good time to make the inevitable severance.

Yet if Pearce saw this as a good time for him to retire, company officials in Boston did not. They delayed action on his resignation for several months. The reason was simple. Troubled over the firm's declining prosperity, Converse and others in the eastern management were beginning to question the integrity of the western staff. Pearce's retirement looked suspicious. In November, after an unseemly period of inaction, Hill finally

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urged Converse to have the board of directors adopt "very strong resolutions of deep regret" over the Cornishman's departure. Prodding brought results. The directors finally passed a resolution expressing their gratitude to Pearce, while both Converse and Moses P. White, the corporate secretary, wrote personal letters to the retiring manager. Whether Pearce ever learned about the flurry of suspicion is a matter of conjecture, but it was unfortunate that such suggestions marred the exit of a man who had long played so large a role in the firm's success.[3]

Despite his long years of residence in the United States, Pearce had never acquired American citizenship, and early in 1902 he returned to Great Britain. He intended to spend his remaining years in retirement, but his reputation in metallurgy brought an end to these plans. Soon after his return a smelting enterprise lured him into managing a plant in Liverpool. He also received an offer to stand for Parliament, although this opportunity he declined. Pearce worked several more years in Liverpool, then retired and moved to London. Here he lived out his last years, dying in 1927 a few months before his eighty-eighth birthday.[4]

In the meantime, as Pearce concluded his association with the Boston and Colorado Company, Hill perceived that the firm had entered a new economic environment. ASARCO, of course, was a strong competitor, stronger than anyone the enterprise had yet encountered, but this was only one dimension to the new scenario. What held ever greater portent was the steadily eroding production of mines on the forks of Clear Creek, the smelter's chief market. Hill realized that the decline foreshadowed an end to the prosperity of the firm. In this light he and the eastern management concluded that it might be best to sell the Argo works before profits turned into losses.

This decision prompted talks with the American Smelting and Refining Company. In the summer of 1901 Converse and his eastern associates approached ASARCO and negotiations ensued, but the two sides failed to reach agreement, if indeed they ever bargained seriously. Hope for a sale appeared gone, but in November, months after talks in the East had come to a fruitless end, Hill reported that the Guggenheims' manager in Denver had mentioned informally that he wished to inspect the Argo works and examine the books. Hill did not name the man, but he was probably either James B. Grant or Franklin Guiterman. Hill was rather surprised. He finally resolved to give this person a tour of the smelter and provide him with data on reduction costs, dividends, and ores on hand, but he would not divulge any details of the processes. Such plans, however, proved unnecessary, for the Guggenheims never sent a representative to Argo. By January Hill had concluded that it would be unwise to approach ASARCO again.[5]

While all this was going on, Harold V. Pearce took over as manager of the Argo smelter. He was the natural choice, since he had worked in the plant for some years and knew every aspect of its operation. Pearce assumed his position in July 1901, but Hill could not persuade the eastern management to give the new manager an official appointment until November, probably because of the negotiations with ASARCO. Once the designation came through, Hill asked Converse to give Pearce an annual salary of $5,000 as well as 5 percent of the profits.[6]

Yet if Pearce expected to supplement his pay from profit sharing he was to be disappointed, for the firm's economic position deteriorated in the fall of 1901. In October Hill warned officials in Boston that profits were dependent upon stability in the price of copper, and he feared that the metal's value might decline as much as four cents a pound. In this case the enterprise stood to lose about $88,000. Hill was apparently aware of an impending struggle between the independent producers and the Amalgamated Copper Company, which was about to make an effort to seize control of the market by selling its huge stocks to depress the price and force other enterprises to come to terms. Hill thought that any fall in prices would be temporary and that once Amalgamated and its rivals resolved the struggle they would curtail output and raise the value even above previous levels.

While Hill's views offered solace for the long run, they did little to bring relief during the winter. As the value of copper declined, producers of ore and matte held back shipments to Denver in hope of realizing higher returns later. Fewer con-

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signments, however, created problems at the smelter, for the metal was essential in the Argo process. With supplies of copper running short, Pearce and Hill decided to recycle what stocks they had on hand so that they could continue working gold and silver ores. But this decision coupled with the low price brought on the loss Hill had predicted.[7]

This combination of events—Pearce's unexpected resignation, the failure of talks with ASARCO, and Hill's predictions of a loss—created suspicion in Boston. In a letter to Hill, Converse questioned the integrity of the western management and suggested an examination of the books to determine if there had been any chicanery. Hill took exception to this. He declared that there was "no question for any concern about the honesty" of the Argo personnel. His uncle, Jesse D. Hale, controlled the local checking account and the Pearces handled all the company drafts. Hill's assurances caused the problem to pass over for the time, but the suggestion of corruption surfaced again in a later year.[8]

Hill had forestalled the question of integrity, but he had no such luck in handling the scarcity of copper-bearing ores; they remained in short supply even though the price of copper rose in 1902, just as he had predicted. The sale of the Butte enterprise had already eliminated Montana as a dependable source of mineral, and smelter construction in other towns had cut off additional markets. And now ASARCO electrolytically refined the matte produced in its own blast furnaces. This not only removed another source of base metal but also did away with still another lucrative portion of Argo's business. In reflecting on the problem in later years, Harold V. Pearce said that it was not until the abundant supplies of copper vanished early in the century that the company came to realize just how valuable the metal was in smelting ores.[9]

In addition to the dearth of copper, Hill and Pearce found themselves confronted with shortages of good grades of smelting rock, for the mines of Clear Creek and Gilpin counties, always the largest sources of ore, were at last beginning to play out. Like J. B. Grant and Franklin Guiterman of ASARCO, Hill and Pearce tried to stimulate more energetic development by increasing returns as market conditions permitted, and on occasion they met with producers to negotiate special reduction rates. The opening of the so-called Moffat Road—the Denver, Northwestern & Pacific Railway—lowered some transportation costs, but neither lower smelting fees nor reduced freight tariffs could reverse the decline in the fortunes of the traditional minerals industry.[10]

Despite the gloomy trend, Pearce and his assistant, F. C. Knight, continued to initiate technical changes that lowered reduction costs still further. For one thing, they devised a method to calculate the precise amounts of gold, silver, and copper lost in reduction so that they could determine which slags might be profitably resmelted. For another, they developed a skimming technique to collect a very low grade of matte that in more prosperous days had been discarded. This innovation also halved the number of men required to remove slag from the reverberatory furnaces.[11]

Bad luck also accelerated Argo's decline. On the night of September 7, 1906, a blaze broke out in the refinery. Firemen brought the conflagration under control before it engulfed the entire plant, but the refinery was a total loss. Hill telegraphed word of the disaster to Boston, and Converse called an emergency meeting of the directors to consider what alternatives were available. Finally, the board decided to accept Hill's advice not to rebuild on the grounds that the firm had little prospect of making money with the old process, which was now obsolescent. Instead, Converse and his colleagues resolved to sell the furnace product to ASARCO. Over the next few years Pearce shipped the smelter's production to Omaha.[12]

The decision to sell matte to ASARCO eliminated the rationale for keeping Richard Pearce's method a corporate "secret." The scientific community had long speculated on the details of the process, and now with the refinery gone to rubble Rossiter Raymond dispatched a letter to Harold V. Pearce asking him to reveal the procedures. Both Hill and Pearce thought this a good idea, and the directors concurred. Having secured official approval, Pearce drew on his father's notes and wrote an article that Raymond had published in the *Transactions of the*

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American Institute of Mining Engineers. It contained the details Richard Pearce had been unable to discuss in his presidential address to the society nearly twenty years before.[13]

Three years after the great fire that destroyed the refinery, the declining fortunes of the company brought on a serious discussion of liquidation. Talk surfaced at the annual meeting held at Argo in April 1909. Hill and others pointed out that since 1900 five years of profitable operations had been more than offset by four years of deficits that had left the firm with a net loss of $60,000. In light of the unpropitious outlook for the minerals industry, as well as the continued inability of the smelter to get adequate supplies of ore, the directors authorized Hill to reduce operations to the lowest possible level and discharge all unnecessary workers. Hill and his associates, however, were still unwilling to make the decision to dissolve the corporation, although events were obviously moving in that direction.

The debate over the company's future came to a climax that summer. In the course of his vacation Hill worried about financial problems and the question of restoring profitability. When he returned to his Denver offices in August, he suggested to officials in Boston that the enterprise be dissolved. Converse agreed. He instructed Hill to convert everything possible into cash and to purchase only those ores necessary to process what already lay on the smelter grounds. While Hill sought legal counsel about the procedures for liquidating a Colorado corporation, Converse called a special meeting of the directors to consider the matter formally, although there was no question about the outcome. The board assented. On September 20, Converse sent all stockholders a letter reviewing the financial condition of the firm and noting its gloomy prospects. He enclosed proxies and urged each shareholder to sign and return them so as to empower the directors to vote for dissolution at a special meeting scheduled for early November. The response in favor of winding up the enterprise proved overwhelming, and the directors set November 2 as the day for the stockholders to consider the question.[14]

Shortly before the meeting, legal technicalities—ostensibly—

led to Converse's resignation as the company president. Under Colorado law the chief executive of a corporation about to be dissolved had to swear under oath that nefarious activities had not been the cause of the firm's demise. Converse was amenable to signing an affidavit about matters within his personal knowledge in Boston, but he was reluctant to sign the required document on the grounds that he was unfamiliar with daily operations at Argo. Converse must still have suspected the western management of financial deception. He volunteered to resign as president if Hill would assume the office and the concomitant responsibilities. When the resident director agreed, he was elected on November 1. And so, on the day before the stockholders met to vote on dissolution, a member of the Hill family, chief architects of the firm's destiny for more than four decades, became president of the company.[15]

All that now remained were the formalities. On November 2, 1909, Hill, Jesse D. Hale, and several associates gathered in the offices at Argo. Holding proxies on behalf of 92 percent of the stockholders, they voted to dissolve the corporation. Later that month Hill filed the official papers with the state of Colorado, and the decision became final on January 13, 1910. Operations at Argo continued for another two months until Saint Patrick's Day, March 17, when Hill's workers extinguished the fire in the last reverberatory furnace. After forty-three years in the business, the Boston and Colorado Smelting Company had processed its last ton of ore.[16]

The fires may have been out, but it took Hill and his successors another forty years to liquidate the firm's assets. At the start the trustees sold some of the houses surrounding the smelter to former employees. Firms in the metropolitan area purchased some machinery. The rest went for scrap. Wreckers demolished the furnaces, and Hill and Hale sold what slag remained to the Globe smelter and other plants for reprocessing. The Colorado & Southern Railway—the old Colorado Central line—bought several tracts of land. By 1921 all that remained of the Argo works was an empty office building with broken windowpanes, a ghostly reminder of the company's glory.

The trustees sold the remaining real estate in Denver very

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slowly. Land values collapsed in the economic recession that followed World War I, and they remained low throughout the twenties and thirties and into the forties. Hill and his successors decided to hold onto the property rather than sell in such an environment. Not until after World War II, long after Hill and Converse had died, did prices rise to the point where a new generation of trustees decided to sell the land to individuals, new firms, and the Public Service Company of Colorado. In May 1950 a Denver law firm mailed a fourth and final liquidation dividend to the descendants of the original stockholders, sent a last official report to the district court, and made the unfortunate decision to have the company papers burned.[17]

Despite the problems confronting the mining industry during the late nineteenth and early twentieth centuries, another generation of entrepreneurs turned their attention toward pyritic smelting. This process had had its inception in the late 1880s and was applied early at Leadville with the formation of the old Bi-Metallic Smelting Company of Smith, Moffat, and Ballou. The company had some success, although the method failed to live up to expectations. Nonetheless, the technique had the potential of reducing profitably the vast quantities of low-grade mineral bearing silver, gold, copper, and iron. The process had particular appeal to owners of isolated mines because the smelting yielded a matte that could be shipped to refineries, whereas the ores themselves were so poor that they could not otherwise be mined, shipped, roasted, and reduced.

Except for the Bi-Metallic works in Leadville, the best-known pyritic smelter was the Carpenter plant in Golden. The firm that erected the smelter came into being in September 1900 when Joseph Berry, Ernest Le Neve Foster, and Franklin R. Carpenter organized themselves into a body corporate as the Clear Creek Mining and Reduction Company. They set the capitalization at $500,000, although whether they actually invested this amount of money cannot be determined.[18]

Berry, Foster, and Carpenter were well known in mining and smelting circles. Berry and his brother owned the Saratoga mine and other properties near Idaho Springs. Like Meyer Guggenheim, the Berrys wished to erect their own smelter to avoid the reduction-charges levied by the Globe, Grant, and Argo smelters. Foster had earned a fine reputation as a mining engineer who used Denver as the hub of his activities throughout the West. Carpenter was a metallurgist long identified with the pyritic process, most notably at Deadwood, South Dakota, where he had operated the picturesquely named Deadwood and Delaware Smelting Company. He also had an excellent reputation, although that astute investigator James D. Hague thought the Deadwood facility badly managed.[19]

With the Clear Creek firm organized, the Berry brothers, Foster, and Carpenter went ahead with their plans for a new pyritic smelter. They selected Golden as the location for the works, since this would allow ore cars to run downgrade from Clear Creek and Gilpin counties, a standard reason for building in the "valley." The enterprise purchased a tract of land bordered by the Colorado & Southern Railway and let construction contracts for a plant that would have two blast furnaces with an aggregate capacity of more than 250 tons daily.

The company caused a stir in the Clear Creek ore markets, and as Carpenter pushed the smelter to completion in July 1901, its two major rivals altered their pricing schedules to meet the competition. The Boston and Colorado enterprise took action first, when it advanced its returns on certain classes of mineral.Then, as soon as Carpenter made his first purchases from local mines, ASARCO increased its pay on shipments of low-grade iron concentrates essential in the pyritic process. The struggle was on.

From the outset Carpenter and his associates confronted a host of problems. Soon after the smelter began operations, they learned that the cast-iron water jackets on the reduction furnaces were defective. Carpenter had to suspend work until the firm could install new units. When he finally resumed smelting, he found that he could not get enough ore to run at full capacity. The Berrys' Saratoga mine could not produce more than a quarter of what the plant required. To get additional supplies, Carpenter eliminated his penalty on silica, increased ore prices, and leased the Pewabic group of mines in Gilpin County, but to no avail. More mineral was not forthcoming. As a last resort, Car-

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penter reduced the wages of his smelter workers, but this only touched off a strike that shut down the plant. On September 11, 1903, after little more than two years in business, the Clear Creek company closed indefinitely. Rumors circulated that the plant had never earned a profit.[20]

But if Carpenter and his associates were through, the smelter was not, or at least not yet. After a year-long hiatus, it was leased to the Independent Smelting and Refining Company, a venture organized by three entrepreneurs from Denver—Marcus A. Bettman, Theodore Marx, and Robert S. Billings. From the name they chose, it appears that they hoped to profit from opposition to ASARCO, and they set the capitalization at $1,000,000, although this hardly represented real money invested in the enterprise.

Bettman and his associates tried to avoid the mistakes of their predecessors. They remodeled the plant, purchased new machinery, built more railroad track, and accumulated an ore supply, albeit a small one. But cognizant that mineral shortages had ended the career of Carpenter's group, Bettman and his colleagues acquired sampling agencies in Idaho Springs, Black Hawk, and Boulder. They also secured lower freight tariffs and then put the smelter into operation in September 1904.

From the outset operations went badly. At this stage in their development, the mines north and west of Denver just could not supply enough smelting rock to meet the needs of the Globe, Argo, and Independent plants. Bettman and his associates could never get the ores they needed, and what was more, bad roads curtailed shipments to Golden. After scarcely nine months in business, the Independent Company blew out its furnaces. Bettman tried to raise new capital in New York, but he had no success. The firm went into receivership, and the plant reverted to the Clear Creek enterprise.[21]

The smelter lay idle for another five years until 1910, when a third group of entrepreneurs decided to try their hand at pyritic reduction. The chief figure was H. A. Reidel, president of the North American Smelter and Mines Company. He and his associates had worked mining properties above Clear Creek for some time, but now they wished to integrate their operations forward into ore processing. After taking possession of the plant, they appropriated a reported $35,000 for renovation and improvements, and Reidel hired two experienced men as superintendent and manager.

Like Bettman's group, Reidel and his associates tried to ensure themselves of adequate ore supplies. They bought additional mines near Idaho Springs and Georgetown and had the good fortune to acquire the contracts of another pyritic smelter that had recently failed after a short career. Reidel's men also happened to discover $100,000 worth of ores abandoned on the grounds of the old French smelter that had worked briefly in Golden during the late 1870s. And the North American venture had fortuitously chosen to enter the reduction industry just at the time the Boston and Colorado firm closed its doors, thus removing a major competitor.

In April 1910 Reidel and his associates set their first pyritic unit in blast. They ran the works as best they could, but neither hope nor plans nor luck could overcome the diminished production of smelting ores from the mines above Clear Creek. After a little more than a year in the industry, the North American firm ceased operation late in 1911. The enterprise went into receivership when Reidel and his associates defaulted on their bonded debt, which by then was on the order of $500,000. This was the final attempt to run the Carpenter smelter. Some time later wreckers demolished the plant.[22]

To some extent the story of Clear Creek, Independent, and North American firms typified the experience of many enterprises that erected pyritic smelters. The process appealed to many mineowners, particularly those working low-grade ores in relatively isolated areas. Plants appeared at Alma, Leadville, Florence, Robinson, Ouray, Silverton, and many other camps. Yet these operations rarely, if ever, lived up to expectation. Profit margins were always narrow, and most firms failed to stimulate enough ore production to make smelting economically feasible. Except for the Bi-Metallic plant in Leadville, few pyritic plants remained in business more than several months.[23]

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Colorado Company, and the failure of so many pyritic outfits, there was one enterprise—a new one—that had a fair success during these troubled times. This was the Ohio and Colorado Smelting Company, which erected a plant at a key railroad junction in the mountainous country and thus reversed the long-term trend toward building major smelters on the plains.

The events that led to the construction of this plant began in 1897 with the formation of the New Monarch Mining Company. The key figures were John C. Kortz and William A. Miles, both of Cleveland, Ohio, and Timothy Goodwin, a mining man from Leadville. They set the capitalization at $1,000,000 divided into one million shares, most of which were exchanged for the outstanding stock of the Australian Mining Company, the Monarch Gold Mining Company, and other firms holding property in Leadville. Kortz took charge as president of the venture, although Goodwin directed all operations. For the next few years the New Monarch enterprise shipped its ore production either to local works or to the valley smelters, but Kortz and his associates found the arrangement unsatisfactory. They disliked the idea of sharing profits with reduction firms like ASARCO. They also had a bad experience in 1901 when the Boston Gold-Copper Company, a short-lived pyritic smelter in Leadville, went out of business owing them a reported $58,000 in returns. And so during this time Kortz and his associates explored the possibility of erecting their own reduction plant.[24]

The discussions led in 1901 to the formation of the Ohio and Colorado Smelting Company, a firm composed largely of the officers, directors, and stockholders of the mining enterprise. Kortz became president, Miles secretary, and Goodwin general manager, the same positions they held in the mining venture, thus continuing the tradition of informal integration seen throughout the reduction industry. Once they had the smelter in operation, they intended to process the entire output of their mines, but since these properties could furnish no more than about a quarter of the projected smelting capacity, Kortz and his colleagues planned to draw upon the production of mines throughout central Colorado.

Rather than build a small plant that might prove to be a low-volume, high-cost operation—and thus doomed—Kortz and his associates drew up plans for a major smelter that could take advantage of the economies of scale. They intended to build twenty-five ore bins that would hold fifty thousand tons of smelting rock. And they would erect four blast furnaces with a capacity of six hundred tons of silver-lead mineral daily plus another two units that could process five hundred tons of copper-bearing ores. Kortz and his colleagues were about to construct a plant second in size only to the Arkansas Valley works in Leadville.

Such ambitious plans required the most careful planning, for both the location and railroad service were crucial if the firm was to have any chance of success. Kortz and his associates debated the alternatives—Denver, Pueblo, and Leadville—then decided upon Salida, a town about sixty miles south of the carbonate camp. Salida had four railroad lines that would give the plant ready access to metallurgical coal from Crested Butte and ores from the San Juan, the old Monarch district, and Leadville. Building at Salida also meant that most fuel and ore could roll downhill to the smelter, and that transportation costs would be far less than if they had to travel as far as Denver or Pueblo or across the plains to Kansas City or Omaha.

Kortz and his colleagues now bent themselves to the task of converting a paper corporation into a working industrial unit. For the plant site, they purchased an entire mesa that faced southwest toward the snowcapped peaks of Saguache and Chaffee counties. Goodwin took the responsibility for erecting the works in addition to managing the mines in Leadville. He hired construction workers, signed contracts for machinery, and attended to all details once construction began late in 1901. Work continued through the hard Salida winter. By April 1902, Goodwin's men had completed the foundations for all major buildings and were momentarily expecting the blast furnaces to arrive from the Colorado Iron Works in Denver. About this time Kortz and Goodwin decided to set July 1 as the target date for beginning the reduction of ore to bullion, but one delay after another crept into the plans, forcing the enterprise to push the time ahead to fall. Finally, Goodwin activated his

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smelting units, and by November he had three furnaces in blast.

The plant drew ore supplies from many districts. The New Monarch enterprise shipped its entire output to Salida, but, as expected, the mineral provided only about a fourth of what the works needed to run at capacity. Yet the firm proved itself competitive in many markets. Goodwin obtained large shipments of smelting rock from Silver Cliff, Bonanza, and Leadville. Small consignments arrived from Gunnison and Hinsdale counties. Even the old Monarch district staged a short renaissance once the smelter opened. Mines in Colorado provided the bulk of the mineral, but they could no longer provide the lead essential in the reduction process. For this Kortz and Goodwin had to look far afield. Mines in the Northwest had the required mineral, and here Kortz and Goodwin signed contracts with producers in the Coeur d'Alene and even as far away as British Columbia.[25]

Meanwhile, the failure of the Boston Gold-Copper Company presented Kortz and his associates with an opportunity to expand and integrate operations only a short time after the Salida works came on stream. The Boston firm owned a pyritic smelter that had proved none too successful, like most such plants, but Kortz and Goodwin thought that if they acquired the plant they might use it to process extremely low grade sulfides in Leadville and ship the furnace product to Salida for resmelting. With this intent Miles bought the property and assets of the Boston firm for the account of the Ohio and Colorado enterprise. Kortz, Goodwin, and Miles reorganized the venture as the Republic Smelting and Refining Company and set the works back in operation. It was reported that they intended to double the capacity from five hundred to a thousand tons daily, but if this was true they soon changed their minds. The smelter never proved renumerative. Late in 1903, after operating the plant for about a year, they decided to abandon it and confine their reduction work to Salida.[26]

Meanwhile, Kortz and Goodwin expanded the Ohio and Colorado smelter. Early in 1903 the directors appropriated a sum reported as $100,000 to erect a sulfide mill for processing the huge quantities of low-grade material shipped down the Arkansas Valley from Leadville. Goodwin pressed forward with construction during the summer and fall, and when the plant became operational it doubled the roasting capacity. Several years later the firm again increased sulfide capacity, this time through purchasing from ASARCO the rights to install the Huntington-Heberlein process, which was coming into general use throughout the industry.

Kortz and his associates also expanded their ore purchasing. Goodwin dispatched agents to mining districts in Utah and to camps in Idaho outside the Coeur d'Alene. These buyers often received an unexpected assist because some mineowners disliked the practices of ASARCO and feared the quasi-monopoly. Goodwin signed contracts with some companies so frustrated by the "smelting trust" that they wished to send their ores to Salida even though freight charges and reduction fees were somewhat higher. Other shrewd mineowners dealt with the Ohio and Colorado firm merely to keep at least one viable competitor in business. Goodwin's agents were so energetic in finding ores that he increased his work force at Salida to 250 men and reduced as much as eight hundred tons of mineral daily. The bullion he sold to the American Metal Company.

Despite its success, the company could not avoid the labor ferment of that turbulent era. In July 1903, Goodwin tried an eight-hour day for furnacemen as a concession to the hot Salida summer and as an effort to dissuade experienced employees from departing for cooler climates. In the fall he insisted upon a restoration of the twelve-hour day. This the smelter workers opposed, and two-thirds of the force went out on strike. Goodwin and his colleagues curtailed operations but continued roasting and smelting on a small scale with nonunion men who crossed picket lines. Like their rivals in ASARCO, Goodwin and his friends had the upper hand, and the strike later ended in failure with the twelve-hour day still in effect.

As Kortz and company expanded operations, they also continued the steady development of their mining properties in Leadville. In 1903 the New Monarch firm began an extensive excavation of its new Cleveland shaft while regular work went forward in the older Winnie, Lida, and New Monarch tunnels.

Over the next few years the enterprise
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Over the next few years the enterprise invested large sums of money in equipment and machinery, and through this, good ore bodies, and good luck, the firm produced about one-tenth of Leadville's output.[27]

Kortz and his associates had the good fortune in 1906 to encounter a remarkably rich streak of ore in the depths of the Winnie shaft. This deposit, only ten inches in diameter, averaged 36 ounces of gold, 77 ounces of silver, and 160 pounds of copper in every ton. The vein itself extended several hundred feet, and its discovery was a lucky reward for the steady efforts to mine and process low grades of mineral. It was just this kind of chance that spurred venture capitalists, if not gamblers, to develop other properties as the mining industry faltered.[28]

In 1907, however, the prices of silver, lead, and copper declined in the wake of the financial crisis of that year, and the newer levels had a deleterious influence on the firms of Kortz and his associates. As values fell, they had to curtail operations at both the New Monarch mines and the Salida smelter, since it was no longer profitable to work the lower grades of ore. Not unreasonably, they assumed that market values would rise once the recession had run its course. As such, Kortz and his colleagues chose this time to install new equipment at their Leadville and Salida properties. The improvements aided both firms, but metals prices unexpectedly remained about the same and would not return to the 1907 level until the United States entered World War I a decade later. In this new economic environment the production of the New Monarch mines fell from two hundred to fifty tons daily, and as shipments of smelting rock fell off throughout the high country owing to prior declines and the exhaustion of ore bodies, the Salida plant found it impossible to run at full capacity.

After 1907 the Ohio and Colorado Company limped along. Kortz and his associates thought a reduction in rail tariffs between the San Juan and Salida might stimulate greater shipments from that quarter, but the hope proved false when the lines lowered their rates. The rising production of zinc-bearing mineral did help the plant, however, for Goodwin bought large quantities of residues from zinc retort smelters in Kansas and

Oklahoma. These materials helped the firm remain in business, but not even the unusually high prices for metal created by World War I could resuscitate the traditional mining industry. The market values of lead, copper, and zinc fell off when the conflict ended in 1918. When the postwar recession eliminated the shipments of zinc residues upon which the plant had come to depend, Kortz and his associates decided to dismantle the plant. The Ohio and Colorado smelter reduced its last ton of ore in 1920.[29]

The demise of the Salida smelter left ASARCO as the only important reduction enterprise in Colorado, once the heart of this industry. Since 1907 the Globe, Pueblo, Arkansas Valley, and Durango works had operated at less than full capacity owing to lower prices for silver, lead, and copper and to the continuing decline of the mining industry based on these metals. Like the Ohio and Colorado Company, the "trust" garnered additional reduction materials through shipments of residues from zinc retort smelters, and they played a large role in keeping the Globe and Pueblo works in operation.

After World War I, however, Daniel Guggenheim and his associates saw their business in Colorado contract even further, requiring new changes in ASARCO's structure. In 1919 the firm decided to halt reduction at the Globe smelter and use the plant solely for treating cadmium, thallium, and indium compounds shipped from other works. Thus Denver, the chief smelting center in the West only two decades before, ceased to be a reduction site at all. Over the next two years the firm witnessed declining shipments of zinc residues from Kansas and Oklahoma to its Pueblo smelter. This matter came to a head in June 1921 when a disastrous flood in the lower Arkansas Valley destroyed a large portion of the works. Once the waters had receded, ASARCO decided that the time had come to close this plant as well.

The demise of the industry at Denver and Pueblo left ASARCO with only the Arkansas Valley and Durango works to process the dwindling output of smelting materials from the high country. Yet now their capacity was more than enough to handle the task. During the 1920s the AV plant reworked old

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slag dumps in Leadville and reduced small quantities of ore mined in the central Rockies or along the eastern slope. The Durango smelter served a few mines near Telluride and elsewhere in the San Juan. Only rarely did either plant have more than one furnace in blast, so miniscule had become the shipments of smelting rock. Then came the severe economic dislocation of the Great Depression, which forced many mines in the San Juan to close down. With that ASARCO closed its Durango works in 1930.

The firm now had only the Arkansas Valley smelter to handle all operations in Colorado. The plant continued working throughout the thirties, but rarely with more than one furnace in blast. The onset of World War II failed to revive the mining industry, but the works still obtained what ores it needed to continue running on a very limited scale throughout the forties, into the fifties, and down until the sixties. Then in 1961 ASARCO decided to close the plant. Nearly a century after James E. Lyon had opened his short-lived works in the town of Black Hawk, the smelting industry in the Rocky Mountains had come to an end.[30]

Throughout its evolution the business of ore reduction followed the great themes that characterized American industrial development during the late nineteenth and early twentieth centuries. Vertical and horizontal integration, centralization, the increased use of capital, the creation of urbanized labor forces, the quest for technological advance, the rise of professional managers, the drive for lower costs, and the rationalization of all aspects of production were just as marked in the smelting industry as they were in petroleum, steel, copper, and many lines of manufacturing. Yet the smelting industry was unique in itself, and its evolution showed that the development of western mineral resources depended largely on the adaptation of European technology and the mobilization of eastern capital.

From its inception in the isolated mining camps of the Rockies, the industry had drawn on metallurgy long used in Europe. Although some men tried their own inventions or tapped inadequate methods used in the East on different types of ore, the shrewdest entrepreneurs consciously sought processes long used in the world-renowned centers of reduction. Nathaniel P. Hill was one of the first in a long line that looked abroad for proved technology. And, like Hill, many businessmen hired skilled laborers, technicians, and metallurgists to install machinery and run plants. Even after the industry had established itself, smeltermen still looked to Europe—witness the adoption of the Huntington-Heberlein process in the early twentieth century. During this time, however, European technologies continued to evolve in the United States as Americans advanced the art and science of ore reduction to process the maximum amount of mineral at the lowest possible cost.

Although the smelting centers of Europe provided much of the technology, the capital that supported the industry came primarily from financial centers east of the Rockies. Wealthy people in Boston and New York invested heavily; others in Philadelphia, Chicago, Kansas City, and St. Louis provided some money; Europeans offered smaller, less significant sums; comparatively little capital came from the Rockies or the West Coast. The stock of most firms was closely held and not listed on any exchange, although this changed somewhat late in the century, particularly after the formation of ASARCO. Throughout this time those holding the controlling interest in most smelters resided far away, as only a few major stockholders made their homes in the Rockies or even in the West. Increasingly, control became centered on New York, the financial capital of the nation.

It was this acquisition of European technology and mobilization of eastern capital to build smelters that permitted many mines to be worked and promoted the economic development of the region. In many districts the smelters stood at the crossroads of exploitation, for, given the metallurgy of the day, only they had the technology needed to recover gold, silver, copper, lead, and other metals from the different types of ore. Without the smelters some minerals might have remained untapped for decades. And in a broader perspective, the smelters stimulated agricultural development, railroad construction, coal mining,

and other industries as well as the gro
and Pueblo.

Despite its international scope, the i
evolutionary pattern typical of "big b
States during the late nineteenth centu
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although they had to sell their bullion
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Later, as individual companies grew
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and converted themselves into interreg
processors. By this time, however, ent
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business.

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Ultimately, of course, the industry d
Many smelters prospered when they had
reduce, but as values declined, ores grew
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cities like Omaha and El Paso and converted the firm into a processor of many metals, a transition already under way by the time of the great merger in 1899. By the onset of World War I, the annual value of the gold and copper marketed by ASARCO exceeded the value of silver and lead, on which the predecessor companies had evolved. And as the years passed, the enterprise became primarily identified with the copper industry and remains so to this day.

Not much remains in the Rockies to remind a passerby of the once-great industry there. No picturesque ruins dot the high country, no bronze statues memorialize the smeltermen, no legends recount past glories. A few slag dumps lie here, an abandoned furnace there, an isolated smokestack pierces the skies somewhere else, but nothing more. A few place names remain—Argo and Globeville in Denver, Eilers Street in Pueblo, Harrison Avenue in Leadville—but not many can recount the origin of the names. The legacy of the business lies elsewhere, primarily in the American Smelting and Refining Company, now officially known as ASARCO, which operates in many locales but only marginally in the Rocky Mountains, once the heart of the industry that created the firm.

Notes

Full details of publication for sources cited a
raphy.

Abbreviations

CHS	Colorado Historical Society
CM	Commonwealth of Massachusetts
CSA	Colorado State Archives
CU	University of Colorado
DPL	Denver Public Library
EMJ	*Engineering and Mining Journal*
FRCD	Federal Records Center, Denver
HEH	Henry E. Huntington Library an
HU	Harvard University
MSP	*Mining and Scientific Press*
NA	National Archives and Records S
NYPL	New York Public Library
YU	Yale University

United States Department of the Interior

TAKE PRIDE IN AMERICA

GEOLOGICAL SURVEY
BOX 25046 M.S. 911
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

IN REPLY REFER TO:

October 1, 1992

Mr. Macon Cowles
Macon Cowles & Associates
1680 Wilson Street
Boulder, Colorado 80304

Dear Mr. Cowles:

Under separate covers I am sending to you and Mr. Murane computer lists of analyses of samples in the Denver Front Range Urban Corridor Study. You requested this information under the Freedom of Information Act on September 3, 1992, and Mr. Murane informally joined your request later. An explanation of the column headings is given on the attached sheets. I should be glad to discuss with either of you any questions that you might have.

I hope this meets your request satisfactorily.

Sincerely yours,

Harry A. Tourtelot
Assistant Chief Geologist
Central Region

Copy to: W. Murane

Data from Tourtelot computer lists provided 10/1/92. (excerpt).

PROJECT: GLOBE PLANT TABLE
DENVER, CO FRONT RANGE URBAN CORRIDOR I
CLIENT: ASARCO FROM H. TOURTELOT, U.S.G.S.
DENVER METROPOLITAN AREA

FN = USGS03.WQ1

OCTOBER 13, 1992

SAMPLE CONCENTRATION (mg/kg)

SAMPLE AREA	LINE NO.	ARSENIC	(LOG)	LEAD		ZINC SPECTRA		ZINC AA	
91	381	6.89	1.9	50	3.912	0	ERR	89	4.5
	382	5.69	1.7	70	4.248	0	ERR	133	4.9
SUB	383	6.05	1.8	50	3.912	0	ERR	134	4.9
	385	6.64	1.9	30	3.401	0	ERR	67	4.2
92	386	7.75	2	200	5.298	0	ERR	163	5.1
	388	7.48	2	50	3.912	0	ERR	91	4.5
URBAN	389	9.55	2.3	100	4.605	0	ERR	190	5.2
	390	5.14	1.6	20	2.996	0	ERR	95	4.6
183	789	2.21	0.8	20	2.996	0	ERR	65	4.2
	790	3.85	1.3	50	3.912	0	ERR	60	4.1
URBAN	791	13.8	2.6	200	5.298	300	5.7	465	6.1
	792	4.81	1.6	50	3.912	0	ERR	90	4.5
93	391	4.67	1.5	100	4.605	0	ERR	166	5.1
	392	2.54	0.9	50	3.912	0	ERR	65	4.2
URBAN	393	7.16	2	70	4.248	0	ERR	62	4.1
	394	2.71	1	100	4.605	0	ERR	85	4.4
99	420	8.12	2.1	100	4.605	0	ERR	166	5.1
	421	5.94	1.8	70	4.248	0	ERR	143	5
SUB	422	16.3	2.8	200	5.298	0	ERR	296	5.7
	423	28.9	3.4	500	6.215	700	6.55	1350	7.2
100	424	4.41	1.5	300	5.704	0	ERR	378	5.9
	425	5.87	1.8	100	4.605	0	ERR	168	5.1
URBAN	426	20.4	3	300	5.704	200	5.3	485	6.2
	427	26	3.3	300	5.704	300	5.7	500	6.2
101	428	2.96	1.1	150	5.011	0	ERR	69	4.2
URBAN	429	5.46	1.7	200	5.298	0	ERR	375	5.9
(VB-I70 Area)									

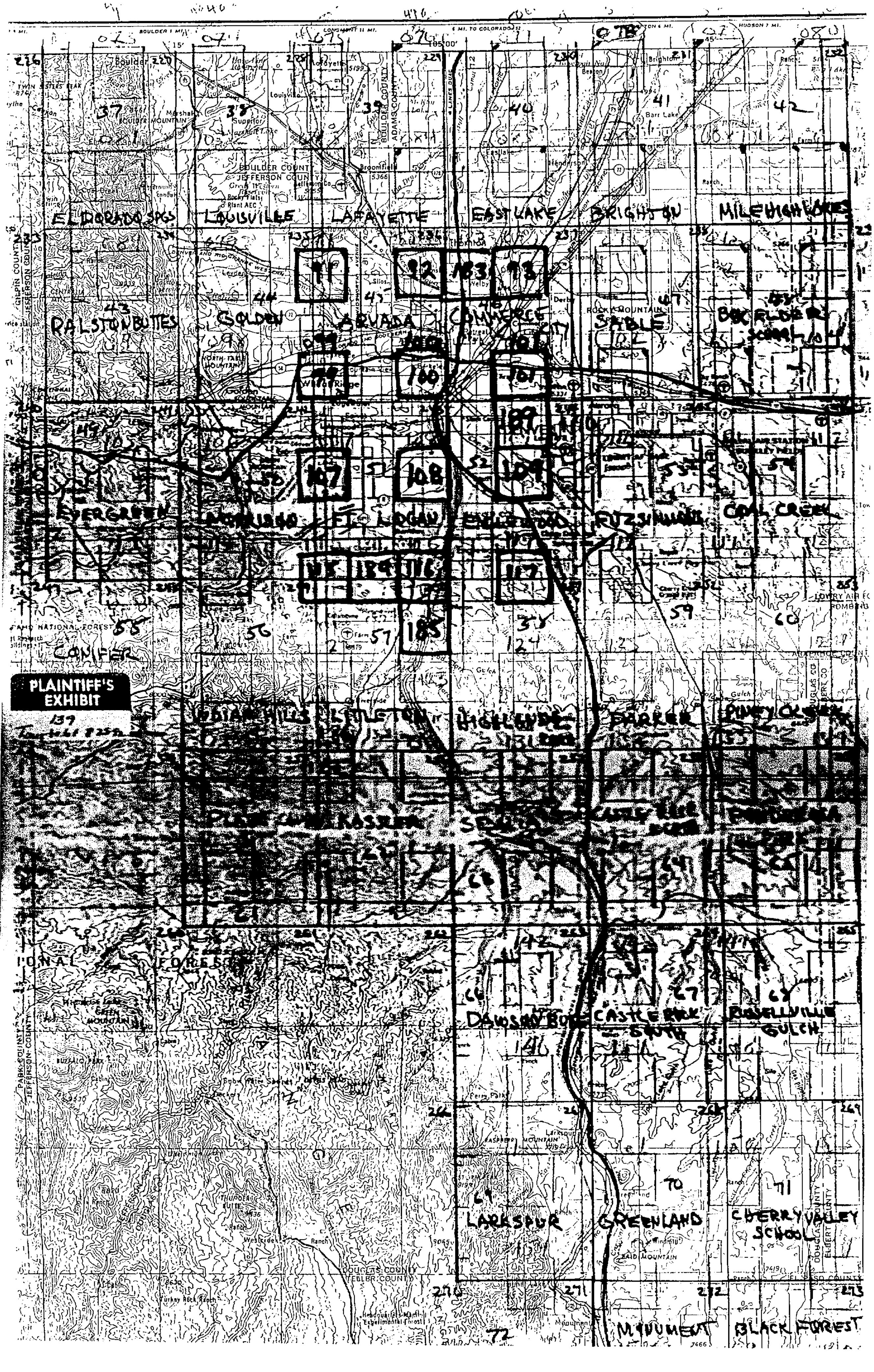
	431	7.89	2.1	100	4.605	0	ERR	88	4.5
	432	17.2	2.8	200	5.298	0	ERR	235	5.5
189	813	42.9	3.8	200	5.298	0	ERR	151	5
	814	82.3	4.4	500	6.215	300	5.7	585	6.4
URBAN	815	11.1	2.4	200	5.298	0	ERR	200	5.3
	816	16	2.8	100	4.605	0	ERR	234	5.5
107	456	9.11	2.2	100	4.605	0	ERR	220	5.4
	457	6.13	1.8	70	4.248	0	ERR	168	5.1
SUB	458	2.89	1.1	30	3.401	0	ERR	106	4.7
	459	3.95	1.4	50	3.912	0	ERR	103	4.6
108	460	4.53	1.5	70	4.248	0	ERR	112	4.7
	461	5.73	1.7	150	5.011	0	ERR	170	5.1
URBAN	462	12.2	2.5	200	5.298	0	ERR	158	5.1
	463	9.25	2.2	100	4.605	0	ERR	333	5.8
109	464	1.74	0.6	100	4.605	0	ERR	28	3.3
	465	2.16	0.8	30	3.401	0	ERR	45	3.8
URBAN	466	4.14	1.4	70	4.248	0	ERR	200	5.3
	467	8.37	2.1	30	3.401	0	ERR	63	4.1
115	491	4.82	1.6	20	2.996	0	ERR	64	4.2
	492	6.12	1.8	30	3.401	0	ERR	65	4.2
SUB	493	8.72	2.2	30	3.401	0	ERR	92	4.5
	494	11.2	2.4	30	3.401	0	ERR	86	4.5
184	793	6.11	1.8	50	3.912	0	ERR	64	4.2
	794	6.81	1.9	30	3.401	0	ERR	73	4.3
SUB	795	4	1.4	30	3.401	0	ERR	80	4.4
	796	4.01	1.4	30	3.401	0	ERR	62	4.1
116	495	3.64	1.3	30	3.401	0	ERR	92	4.5
SUB	496	3.08	1.1	50	3.912	0	ERR	47	3.9
	497	2.58	0.9	100	4.605	0	ERR	68	4.2
117	498	4.72	1.6	30	3.401	0	ERR	81	4.4
SUB	499	7.73	2	150	5.011	0	ERR	97	4.6

	500	5.99	1.8	50	3.912	0	ERR	81	4.4
	502	5.3	1.7	15	2.708	0	ERR	100	4.6
185	797	3.59	1.3	30	3.401	0	ERR	72	4.3
	798	5.25	1.7	50	3.912	0	ERR	60	4.1
SMB	799	4.29	1.5	20	2.996	0	ERR	85	4.4
	800	4.36	1.5	50	3.912	0	ERR	88	4.5

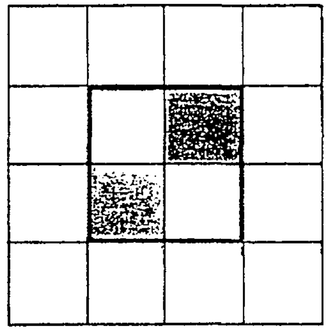
Tourtelot (USGS) Data - Urban Denver Samples

Block	Arithmetic Value (As, ppm)				Natural Log Value			
92	7.75	7.48	9.55	5.14	2.047693	2.012233	2.256541	1.637053
183	2.21	3.85	13.8	4.81	0.792993	1.348073	2.624669	1.570697
93	4.67	2.54	7.16	2.71	1.541159	0.932164	1.96851	0.996949
100	4.41	5.87	20.4	26	1.483875	1.769855	3.015535	3.258097
101	2.96	5.46	7.89	17.2	1.085189	1.697449	2.065596	2.844909
189	42.9	82.3	11.1	16	3.758872	4.410371	2.406945	2.772589
108	4.53	5.73	12.2	9.25	1.510722	1.745716	2.501436	2.224624
109	1.74	2.16	4.14	8.37	0.553885	0.770108	1.420696	2.124654

	ln average	1.973433	ln std dev	0.876185
	geomean	7.195335	geo std	2.40172
geomean	+ 1 sd	17.28118		
	+ 2 sd	41.50457		

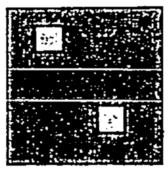

PLAINTIFF'S EXHIBIT
137
ELDORADO SPGS
LOUISVILLE
LAFAYETTE
EAST LAKE
BRIGHTON
MILE HIGH LAKES
RALSTON BUTTES
GOLDEN
ARVADA
COMMERCE CITY
SABLE
EVERGREEN
MORRISON
FT. LOGAN
ENGLEWOOD
FITZSIMMONS
COAL CREEK
CONIFER
INDIAN HILLS
LITTLETON
HIGHLANDS RANCH
PARKER
PINEY CREEK
KASSLER
SEDALIA
DAWSON BUTTE
CASTLE ROCK SOUTH
RUSSELLVILLE GULCH
LARKSPUR
GREENLAND
CHERRY VALLEY SCHOOL
MONUMENT
BLACK FOREST

8 KM



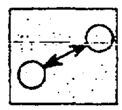
LOCALITIES WITHIN SAMPLE AREA

2 KM

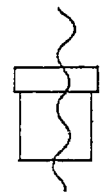


SITES WITHIN LOCALITY

50 M



COMPOSITE SAMPLES WITHIN SITE



SAMPLE SPLIT FOR ANALYTICAL DUPLICATES

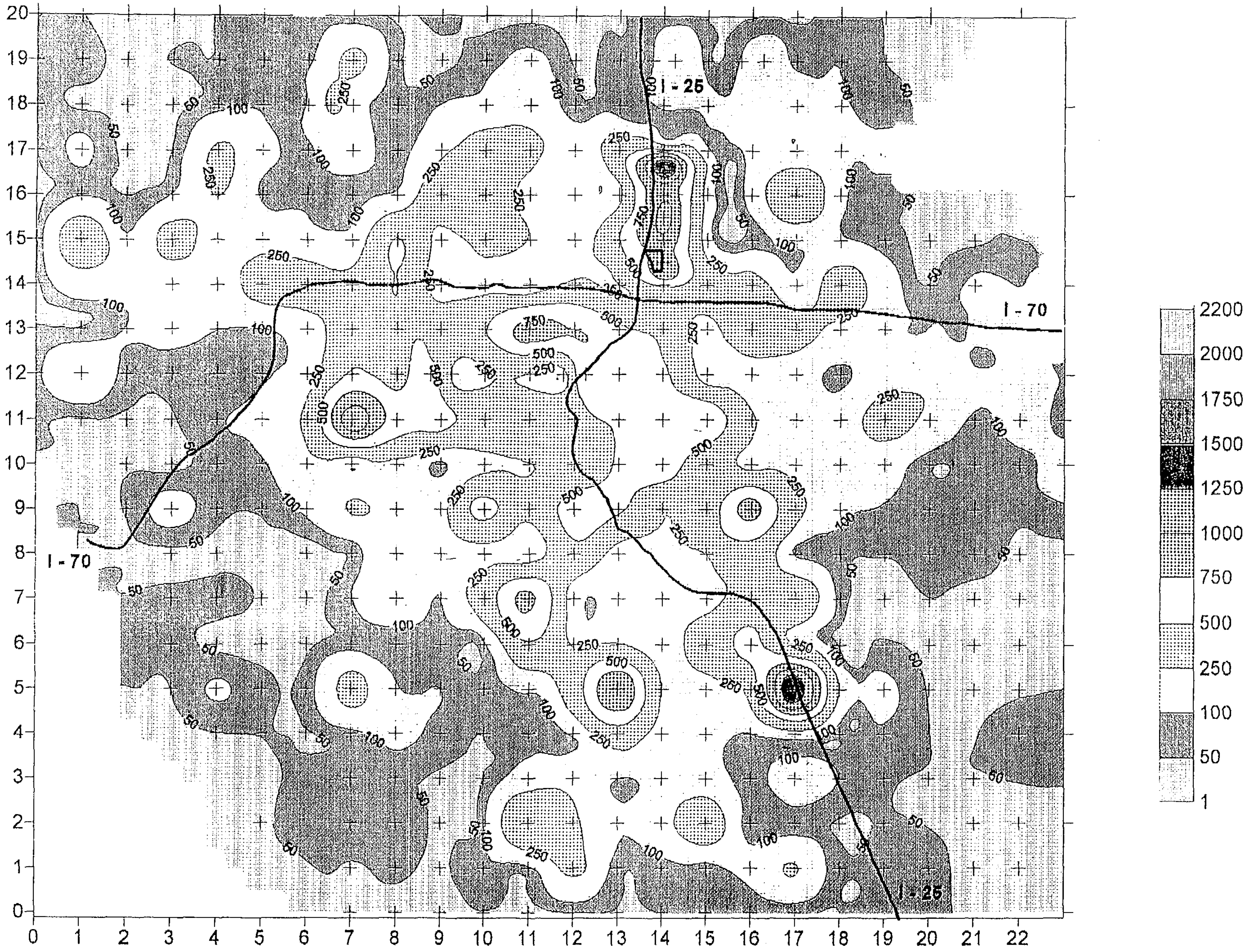
1 COMPOSITE SAMPLE PER SITE

2 SITES PER LOCALITY

2 LOCALITIES PER AREA

SKYLINE SOILS METALS DATA

LEAD



SKYLINE LABS, INC.
SPECIALISTS IN EXPLORATION GEOCHEMISTRY
2090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MVU 995
February 24, 1986

Skyline Labs, Inc.
12090 West 50th Place
Wheatridge, Colorado 80033
Skyline Labs, Inc.
12090 West 50th Place

put in computer spreadsheet

[redacted] # with in 1 mile radius of Globe

ITEM		SAMPLE NUMBER (X Y)	Tourt to skyline maps	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
1	B	DEN-000001-0020-0020	B	20.	40.	100.	1.6	40.
2	B	DEN-000002-0019-0020	B	20.	45.	110.	1.2	50.
3	B	DEN-000003-0018-0020	B	25.	85.	100.	2.4	65.
4	B	DEN-000004-0017-0020	B	15.	35.	85.	1.2	20.
5	C	DEN-000005-0017-0019	C	45.	70.	160.	2.8	110.
6	C	DEN-000006-0016-0019	C	40.	75.	320.	3.0	125.
7	B	DEN-000007-0016-0020		15.	45.	80.	1.6	35.
8	C	DEN-000008-0015-0019		15.	55.	85.	2.0	35.
9	C	DEN-000009-0014-0019		25.	55.	90.	1.6	40.
10	B	DEN-000010-0014-0020		20.	70.	90.	2.0	25.
11	B	DEN-000011-0015-0020		15.	45.	75.	2.0	35.
12	C	DEN-000012-0014-0018		30.	115.	130.	2.2	105.
13	C	DEN-000013-0014-0017		125.	260.	400.	5.0	250.
14	C	DEN-000014-0014-0016		50.	130.	165.	3.2	80.
15		DEN-000015-0014-0015		85.	360.	455.	50.0	300.
16		DEN-000016-0014-0014		65.	300.	530.	11.0	290.
17	C	DEN-000017-0015-0014		65.	400.	980.	4.2	110.
18	C	DEN-000018-0015-0015		35.	60.	110.	2.2	50.
19	C	DEN-000019-0015-0016		20.	95.	220.	11.0	195.
20	C	DEN-000020-0015-0017		55.	70.	155.	2.0	80.
21	C	DEN-000021-0015-0018		65.	120.	190.	2.4	90.
22	C	DEN-00002216.50-0180		200.	350.	650.	1.4	30.
23	C	DEN-000023-0018-0019		35.	105.	270.	2.4	270.
24	B	DEN-000024-0019-0019		20.	45.	80.	1.0	40.
25	C	DEN-000025-0018-0018		15.	100.	95.	1.4	30.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
26	DEN-000026-0017-0018	20.	185.	120.	1.6	35.
27	DEN-000027-0017-0017	30.	85.	120.	2.0	50.
28	DEN-000028-0016-0017	35.	115.	270.	2.6	420.
29	DEN-000029-0016-0016	35.	140.	200.	2.8	45.
30	DEN-000030-0016-0015	20.	40.	85.	1.4	25.
31	DEN-000031-0018-0017	15.	135.	100.	1.2	55.
32	DEN-000032-0018-0016	10.	80.	80.	1.4	25.
33	DEN-000033-0017-0016	15.	605.	185.	1.8	140.
34	DEN-000034-0018-0015	10.	100.	80.	1.6	25.
35	DEN-000035-0017-0015	20.	90.	130.	3.2	35.
36	DEN-000036-0019-0015	20.	55.	90.	1.4	30.
37	DEN-000037-0020-0015	10.	40.	55.	1.0	20.
38	DEN-000038-0021-0015	10.	35.	50.	1.0	20.
39	DEN-000039-0021-0014	10.	130.	70.	1.2	20.
40	DEN-000040-0020-0014	20.	40.	75.	1.4	25.
41	DEN-000041-0018-0014	30.	410.	165.	2.0	80.
42	DEN-000042-0017-0014	15.	80.	80.	1.6	20.
43	DEN-000043-0016-0014	20.	345.	85.	4.2	45.
44	DEN-000044-0017-0013	20.	345.	170.	1.9	40.
45	DEN-000045-0018-0013	20.	205.	110.	1.8	35.
46	DEN-000046-0019-0013	35.	135.	140.	2.0	115.
47	DEN-000047-0016-0013	30.	500.	280.	4.0	185.
48	DEN-000048-0015-0013	25.	150.	220.	2.8	130.
49	DEN-000049-0014-0013	85.	470.	480.	8.6	600.
50	DEN-000050-0014-0012	40.	550.	300.	3.0	800.
51	DEN-000051-0015-0012	20.	130.	160.	1.6	85.
52	DEN-000052-0016-0012	25.	110.	150.	1.6	40.
53	DEN-000053-0017-0012	25.	150.	230.	2.0	420.
54	DEN-000054-0018-0012	20.	50.	90.	1.6	50.
55	DEN-000055-0013-0011	65.	525.	340.	3.4	785.
56	DEN-000056-0014-0011	35.	560.	355.	2.6	315.
57	DEN-000057-0015-0011	45.	780.	215.	3.0	635.
58	DEN-000058-0016-0011	35.	260.	220.	2.2	745.
59	DEN-000059-0017-0011	40.	220.	310.	2.6	155.
60	DEN-000060-0018-0011	30.	160.	300.	2.0	80.

ITEM		SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
61	B	DEN-000061-0019-0011	30.	365.	220.	2.8	260.
62	B	DEN-000062-0020-0011	25.	215.	150.	1.8	240.
63	B	DEN-000063-0021-0011	20.	75.	80.	1.6	50.
64	B	DEN-000064-0022-0011	25.	150.	160.	1.6	55.
65	B	DEN-000065-0023-0011	20.	75.	50.	1.6	35.
66	B	DEN-000066-0023-0010	20.	140.	125.	1.6	60.
67	B	DEN-000067-0022-0010	20.	75.	110.	2.0	65.
68	B	DEN-000068-0021-0010	20.	50.	85.	1.2	35.
69	B	DEN-000069-0020-0010	20.	40.	85.	1.4	35.
70	B	DEN-000070-0019-0010	20.	155.	110.	1.6	50.
71	C	DEN-000071-0018-0010	25.	170.	110.	1.8	25.
72		DEN-000072-0017-0010	35.	190.	240.	2.4	400.
73		DEN-000073-0016-0010	20.	180.	205.	1.8	190.
74		DEN-000074-0015-0010	50.	285.	390.	2.6	245.
75		DEN-000075-0014-0010	45.	675.	510.	2.8	440.
76		DEN-000076-0013-0010	65.	535.	740.	3.4	200.
77		DEN-000077-0013-0009	60.	550.	180.	4.5	265.
78		DEN-000078-0014-0009	30.	245.	245.	2.0	400.
79		DEN-000079-0015-0009	20.	370.	280.	1.8	100.
80		DEN-000080-0016-0009	25.	925.	260.	2.6	850.
81		DEN-000081-0017-0009	20.	305.	105.	1.4	110.
82	C	DEN-000082-0018-0009	20.	105.	105.	1.4	35.
83	B	DEN-000083-0020-0009	15.	60.	70.	1.4	40.
84	B	DEN-000084-0021-0009	20.	105.	90.	1.6	30.
85	B	DEN-000085-0022-0009	20.	60.	145.	1.4	25.
86	B	DEN-000086-0022-0008	10.	25.	30.	1.0	20.
87	B	DEN-000087-0021-0008	15.	100.	90.	1.4	20.
88	B	DEN-000088-0020-0008	10.	70.	55.	1.4	30.
89	B	DEN-000089-0019-0008	10.	50.	50.	1.2	20.
90	C	DEN-000090-0018-0008	20.	60.	100.	1.4	50.
91		DEN-000091-0017-0008	15.	30.	60.	1.2	20.
92		DEN-000092-0016-0008	50.	250.	165.	1.6	70.
93		DEN-000093-0015-0008	25.	240.	170.	1.8	320.
94		DEN-000094-0014-0008	25.	320.	180.	2.0	120.
95		DEN-000095-0013-0008	25.	140.	155.	1.4	40.

ITEM		SAMPLE NUMBER		Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
96	B	DEN-000096-0013-0007	C	15.	100.	85.	1.4	35.
97	B	DEN-000097-0014-0007	C	45.	250.	300.	3.0	50.
98	B	DEN-000098-0015-0007	C	25.	160.	115.	1.4	75.
99	B	DEN-000099-0016-0007	C	25.	345.	180.	1.6	35.
100	B	DEN-000100-0017-0007	C	20.	540.	165.	1.8	115.
101	C	DEN-000101-0018-0007	C	15.	50.	75.	2.0	35.
102	B	DEN-000102-0019-0007		10.	20.	60.	.8	20.
103	B	DEN-000103-0020-0007		10.	55.	45.	1.0	20.
104	B	DEN-000104-0021-0007		10.	15.	40.	.8	25.
105	B	DEN-000105-0022-0007		10.	25.	40.	.8	60.
106	B	DEN-000106-0021-0006		10.	20.	35.	.8	50.
107	B	DEN-000107-0022-0006		10.	20.	35.	1.0	35.
108	B	DEN-000108-0020-0006		10.	30.	45.	1.0	35.
109	B	DEN-000109-0018-0006		25.	35.	95.	1.4	45.
110	B	DEN-000110-0017-0006		25.	75.	90.	1.4	50.
111	B	DEN-000111-0016-0006		25.	630.	190.	1.8	95.
112		DEN-000112-0015-0006		25.	410.	180.	1.8	90.
113		DEN-000113-0014-0006		25.	110.	120.	1.6	50.
114		DEN-000114-0013-0006		55.	210.	325.	2.4	110.
115		DEN-000115-0013-0005		45.	1200.	315.	2.8	130.
116		DEN-000116-0014-0005		30.	205.	160.	1.8	95.
117		DEN-000117-0015-0005		20.	155.	95.	1.4	90.
118		DEN-000118-0016-0005		30.	270.	140.	1.6	95.
119		DEN-000119-0017-0005		25.	1900.	325.	1.8	35.
120		DEN-000120-0018-0005		20.	120.	105.	1.6	35.
121		DEN-000121-0019-0005		30.	135.	120.	1.6	45.
122		DEN-000122-0020-0005		25.	40.	120.	1.6	35.
123		DEN-000123-0021-0005		15.	20.	55.	1.2	20.
124		DEN-000124-0022-0005		35.	40.	90.	1.6	35.
125		DEN-000125-0022-0004		15.	95.	90.	1.2	30.
126		DEN-000126-0019-0004		30.	95.	110.	1.4	40.
127		DEN-000127-0018-0004		30.	55.	105.	1.6	35.
128		DEN-000128-0017-0004		20.	40.	85.	1.2	30.
129		DEN-000129-0016-0004		20.	70.	100.	1.6	35.
130		DEN-000130-0015-0004		25.	130.	120.	1.8	35.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
131 B	DEN-000131-0014-0004	25.	160.	170.	1.6	65.
132 B	DEN-000132-0013-0004	20.	400.	155.	1.8	170.
133 C	DEN-000133-0012-0015	50.	90.	105.	1.8	20.
134	DEN-000134-0012-0014	70.	280.	420.	3.0	90.
135	DEN-000135-0012-0013	30.	820.	210.	2.4	1240.
136	DEN-000136-0012-0012	15.	75.	125.	1.6	60.
137	DEN-000137-0013-0013	90.	570.	420.	11.0	150.
138	DEN-000138-0013-0012	60.	630.	520.	5.0	215.
139	DEN-000139-0011-0012	65.	200.	270.	2.8	370.
140	DEN-000140-0011-0013	35.	1000.	280.	2.8	325.
141	DEN-000141-0011-0014	15.	55.	90.	2.2	30.
142	DEN-000142-0011-0015	125.	275.	320.	4.5	230.
143	DEN-000143-0011-0016	20.	135.	110.	1.4	20.
144	DEN-000144-0011-0017	35.	315.	260.	2.4	150.
145	DEN-000145-0011-0018	20.	200.	95.	1.4	30.
146	DEN-000146-0011-0019	20.	140.	90.	1.4	30.
147 B	DEN-000147-0011-0020	15.	30.	60.	1.2	20.
148 B	DEN-000148-0010-0019	20.	75.	90.	1.6	25.
149 B	DEN-000149-0010-0020	20.	30.	65.	1.6	20.
150 B	DEN-000150-0010-0018	25.	125.	110.	1.6	30.
151 B	DEN-000151-0010-0017	55.	370.	230.	1.8	155.
152 B	DEN-000152-0010-0016	30.	485.	165.	1.2	40.
153 B	DEN-000153-0010-0015	100.	330.	335.	1.6	280.
154 B	DEN-000154-0010-0014	35.	180.	145.	1.6	50.
155	DEN-000155-0013-0014	40.	155.	300.	1.8	60.
156	DEN-000156-0013-0015	45.	550.	250.	5.2	50.
157 C	DEN-000157-0013-0016	65.	105.	305.	2.8	80.
158	DEN-000158-0013-0017	50.	390.	130.	2.0	40.
159	DEN-000159-0013-0018	25.	65.	85.	2.0	35.
160	DEN-000160-0013-0019	25.	70.	95.	1.6	35.
161 B	DEN-000161-0013-0020	20.	50.	85.	1.4	30.
162 B	DEN-000162-0012-0020	15.	35.	60.	1.2	20.
163 C	DEN-000163-0012-0019	15.	35.	60.	1.2	25.
164	DEN-000164-0012-0018	25.	50.	80.	1.2	30.
165	DEN-000165-0012-0017	25.	130.	120.	2.0	75.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
166 C	DEN-000166-0012-0016	60.	150.	180.	2.4	165.
167 D	DEN-000167-0010-0013	85.	520.	240.	7.0	110.
168	DEN-000168-0010-0012	30.	205.	155.	1.4	60.
169	DEN-000169-0009-0012	40.	690.	260.	1.8	1290.
170	DEN-000170-0009-0013	30.	460.	205.	1.6	325.
171	DEN-000171-0009-0014	40.	100.	200.	1.6	180.
172	DEN-000172-0009-0015	65.	135.	155.	1.4	210.
173	DEN-000173-0009-0016	50.	460.	125.	1.0	90.
174	DEN-000174-0009-0017	25.	205.	150.	1.6	720.
175	DEN-000175-0009-0018	20.	95.	95.	1.6	200.
176	DEN-000176-0009-0019	15.	30.	65.	1.2	160.
177	DEN-000177-0009-0020	35.	65.	130.	1.4	430.
178	DEN-000178-0008-0020	20.	40.	75.	1.4	90.
179	DEN-000179-0008-0019	30.	55.	110.	1.6	120.
180	DEN-000180-0008-0018	25.	50.	95.	1.4	120.
181	DEN-000181-0008-0017	15.	45.	70.	1.4	15.
182	DEN-000182-0008-0016	30.	80.	150.	2.4	50.
183	DEN-000183-0008-0015	40.	600.	255.	2.0	135.
184	DEN-000184-0008-0014	65.	530.	110.	2.2	155.
185	DEN-000185-0008-0013	130.	475.	460.	2.6	390.
186	DEN-000186-0008-0012	75.	360.	500.	3.4	170.
187	DEN-000187-0007-0012	25.	530.	155.	1.8	115.
188	DEN-000188-0007-0013	70.	365.	240.	1.8	165.
189	DEN-000189-0007-0014	100.	300.	295.	2.0	200.
190	DEN-000190-0007-0015	20.	100.	100.	1.2	50.
191	DEN-000191-0007-0016	30.	60.	160.	1.2	65.
192	DEN-000192-0007-0017	80.	175.	255.	1.6	165.
193	DEN-000193-0007-0018	50.	125.	225.	1.8	140.
194	DEN-000194-0007-0019	230.	330.	600.	3.5	340.
195 D	DEN-000195-0007-0020	20.	60.	90.	1.6	145.
196 C	DEN-000196-0012-0012	75.	800.	340.	3.2	120.
197	DEN-000197-0012-0011	70.	425.	440.	2.6	190.
198	DEN-000198-0012-0010	40.	245.	190.	1.6	35.
199	DEN-000199-0012-0009	40.	690.	270.	2.6	470.
200	DEN-000200-0012-0008	25.	480.	170.	1.6	130.

SKYLINE LABS, INC.
SPECIALISTS IN EXPLORATION GEOCHEMISTRY
12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MVU 997
February 24, 1986

Skyline Labs, Inc.
12090 West 50th Place
Wheatridge, Colorado 80033

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
1 B	DEN-000201-0012-0007	40.	70.	110.	1.2	50.
2	DEN-000202-0012-0006	60.	195.	175.	1.8	100.
3	DEN-000203-0012-0004	20.	40.	75.	.8	35.
4	DEN-000204-0011-0004	30.	75.	95.	1.6	115.
5	DEN-000205-0011-0005	50.	100.	110.	1.2	35.
6 B	DEN-000206-0011-0006	40.	530.	180.	1.8	120.
7 C	DEN-000207-0011-0007	35.	980.	230.	2.0	110.
8 C	DEN-000208-0011-0008	35.	70.	110.	1.2	20.
9 C	DEN-000209-0011-0009	30.	240.	150.	1.8	45.
10 C	DEN-000210-0011-0010	30.	235.	220.	2.6	75.
11 C	DEN-000211-0011-0011	40.	500.	480.	3.0	95.
12 B	DEN-000212-0010-0011	155.	440.	610.	3.4	350.
13 B	DEN-000213-0010-0010	40.	165.	160.	1.8	130.
14 B	DEN-000214-0010-0009	30.	680.	215.	2.2	50.
15	DEN-000215-0010-0008	40.	155.	210.	2.0	110.
16	DEN-000216-0010-0007	45.	415.	120.	1.6	120.
17	DEN-000217-0010-0006	30.	25.	110.	1.6	35.
18	DEN-000218-0010-0005	25.	55.	85.	2.0	35.
19	DEN-000219-0010-0004	30.	45.	95.	1.6	35.
20	DEN-000220-0009-0004	20.	80.	90.	1.2	20.
? 21	DEN-000221-0009-0005	20.	110.	110.	1.2	35.
22	DEN-000222-0009-0006	30.	55.	115.	1.4	30.
23	DEN-000223-0009-0007	40.	75.	115.	1.2	30.
24	DEN-000224-0009-0008	115.	155.	360.	2.2	165.
25	DEN-000225-0009-0009	40.	185.	170.	2.0	60.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb 1(ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
26	B DEN-000226-0009-0010	25.	55.	110.	1.2	20.
27	DEN-000227-0009-0011	40.	630.	270.	2.0	450.
28	DEN-000228-0008-0011	30.	660.	195.	1.8	200.
29	DEN-000229-0007-0011	40.	1300.	400.	2.0	125.
30	DEN-000230-0007-0010	40.	100.	140.	1.4	35.
31	DEN-000231-0007-0009	75.	280.	300.	2.0	115.
32	DEN-000232-0008-0010	35.	205.	150.	1.6	40.
33	DEN-000233-0008-0009	50.	240.	300.	2.6	65.
34	DEN-000234-0008-0008	100.	245.	620.	2.8	85.
35	DEN-000235-0007-0008	35.	40.	110.	1.0	15.
36	DEN-000236-0007-0007	35.	100.	130.	1.4	20.
37	DEN-000237-0008-0007	35.	260.	135.	.8	30.
38	DEN-000238-0007-0006	30.	50.	120.	.8	30.
39	DEN-000239-0007-0005	15.	400.	105.	.6	20.
40	DEN-000240-0008-0006	40.	35.	105.	.4	15.
41	DEN-000241-0008-0005	25.	90.	120.	.6	235.
42	DEN-000242-0007-0004	25.	60.	100.	1.0	25.
43	DEN-000243-0008-0004	30.	140.	120.	1.6	90.
44	DEN-000244-0007-0003	20.	70.	100.	1.6	20.
45	DEN-000245-0007-0002	20.	105.	105.	1.0	10.
46	DEN-000246-0007-0001	15.	40.	80.	1.0	30.
47	DEN-000247-0007-0000	25.	50.	200.	2.0	30.
48	DEN-000248-0008-0000	15.	35.	75.	1.2	15.
49	DEN-000249-0008-0001	20.	60.	80.	1.2	15.
50	DEN-000250-0008-0002	20.	85.	90.	1.6	15.
51	DEN-000251-0008-0003	15.	55.	90.	1.6	25.
52	DEN-000252-0009-0002	15.	40.	70.	1.4	15.
53	DEN-000253-0009-0001	15.	40.	65.	1.4	15.
54	DEN-000254-0009-0000	20.	30.	80.	1.4	25.
55	DEN-000255-0010-0000	20.	50.	85.	1.4	35.
56	DEN-000256-0010-0001	20.	90.	110.	1.2	25.
57	DEN-000257-0010-0002	20.	50.	100.	1.6	20.
58	DEN-000258-0011-0002	20.	620.	170.	1.6	335.
59	DEN-000259-0011-0003	20.	135.	110.	1.4	30.
60	DEN-000260-0010-0003	20.	45.	90.	1.6	15.

JOB NO. MVU 997
February 24, 1986
PAGE 3

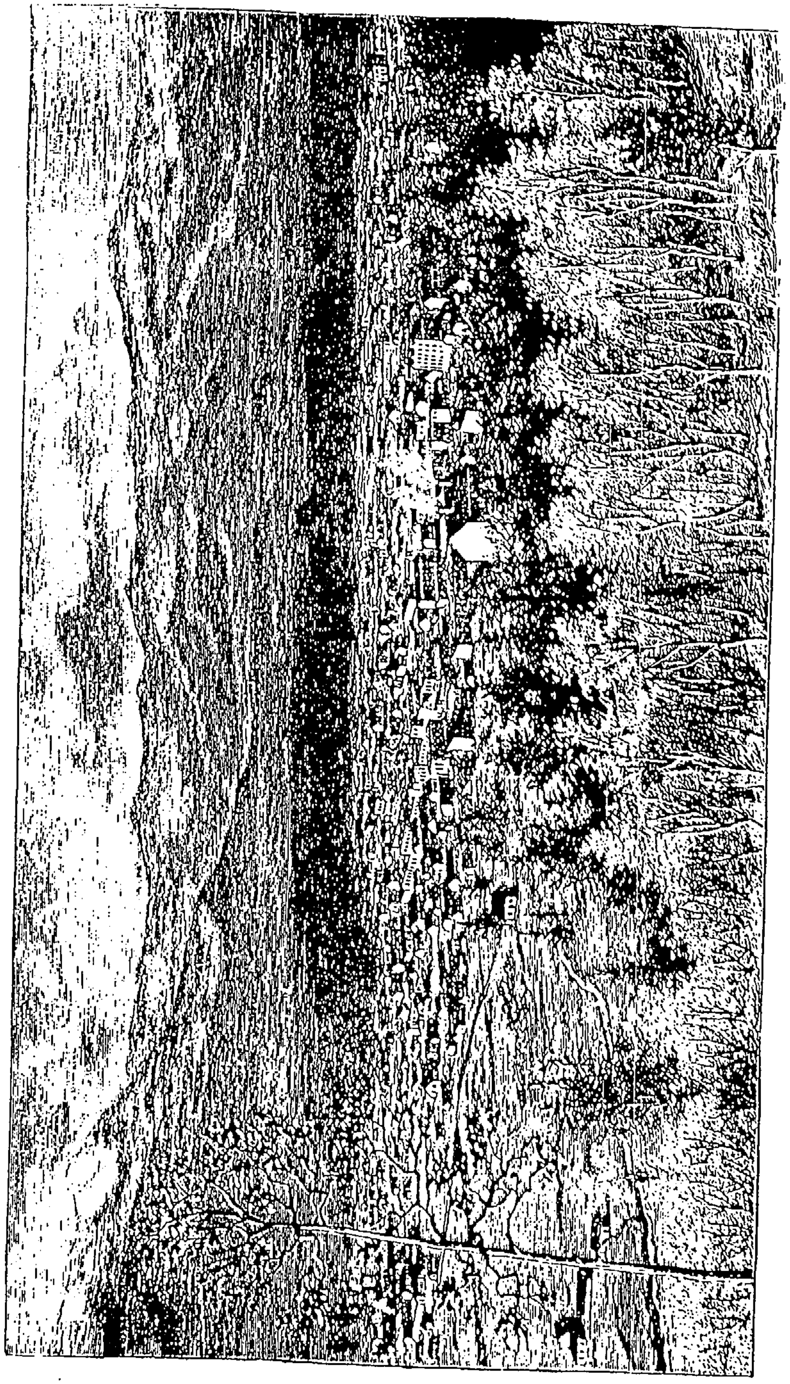
ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
61 B	DEN-000261-0009-0003	20.	40.	110.	2.0	30.
62	DEN-000262-0011-0001	10.	40.	70.	1.2	20.
63	DEN-000263-0012-0003	55.	215.	400.	1.8	80.
64	DEN-000264-0012-0002	35.	270.	205.	1.8	130.
65	DEN-000265-0012-0001	20.	335.	130.	1.6	60.
66	DEN-000266-0012-0000	20.	40.	95.	1.2	15.
67	DEN-000267-0011-0000	15.	35.	90.	1.2	20.
68	DEN-000268-0013-0003	20.	70.	90.	1.4	20.
69	DEN-000269-0014-0003	25.	110.	165.	1.6	30.
70	DEN-000270-0014-0002	25.	200.	240.	2.0	35.
71	DEN-000271-0013-0002	20.	105.	70.	1.6	30.
72	DEN-000272-0013-0001	25.	50.	95.	1.6	15.
73	DEN-000273-0013-0000	30.	45.	95.	1.6	20.
74	DEN-000274-0014-0000	35.	50.	110.	1.4	20.
75	DEN-000275-0014-0001	40.	65.	120.	1.4	30.
76	DEN-000276-0015-0001	25.	60.	105.	1.6	25.
77	DEN-000277-0015-0000	25.	65.	110.	1.6	15.
78	DEN-000278-0015-0002	25.	460.	160.	1.6	30.
79	DEN-000279-0015-0003	20.	145.	130.	1.6	20.
80	DEN-000280-0016-0003	20.	50.	100.	1.6	30.
81	DEN-000281-0017-0003	25.	205.	130.	2.0	20.
82	DEN-000282-0017-0002	25.	50.	95.	1.6	20.
83 B	DEN-000404-0016-0002	20.	40.	85.	1.6	30.
84 B	DEN-000405-0018-0002	25.	40.	100.	1.6	20.
85 B	DEN-000284-0018-0003	25.	100.	110.	1.4	10.
86	DEN-000285-0018-0001	30.	45.	110.	1.4	10.
87	DEN-000286-0017-0001	20.	300.	140.	1.6	35.
88	DEN-000287-0016-0001	25.	130.	115.	1.6	30.
89	DEN-000288-0016-0000	25.	50.	110.	1.6	10.
90	DEN-000289-0017-0000	25.	55.	105.	1.6	30.
91	DEN-000290-0019-0001	25.	80.	110.	1.6	30.
92	DEN-000291-0019-0002	20.	50.	90.	1.4	30.
93	DEN-000292-0019-0003	30.	55.	100.	1.4	20.
94	DEN-000293-0020-0003	20.	40.	70.	1.2	15.
95	DEN-000294-0021-0003	30.	40.	115.	1.4	35.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
96 B	DEN-000295-0021-0002	25.	40.	95.	1.0	15.
97	DEN-000296-0021-0001	25.	35.	95.	1.6	10.
98	DEN-000297-0022-0001	20.	35.	70.	1.2	15.
99	DEN-000298-0022-0002	15.	20.	70.	1.2	15.
100	DEN-000299-0020-0001	N/R	65.	90.	1.6	20.
101	~~DEN-000300-10.5-0040~~	250.	500.	105.	1.6	50.
102	DEN-000406-0014-14.5	345.	1450.	310.	15.2	1500.
103	DEN-000305-0014-15.5	550.	1900.	2700.	8.0	150.
104 C	DEN-000306-~~0014-16.5~~	450.	2300.	1550.	3.2	110.
105 B	DEN-000310-0006-0011	50.	265.	140.	1.2	55.
106	DEN-000311-0006-0010	35.	210.	130.	1.6	25.
107	DEN-000312-0006-0009	35.	115.	130.	1.2	25.
108	DEN-000313-0006-0008	20.	15.	90.	1.0	25.
109	DEN-000314-0006-0007	20.	15.	100.	.6	20.
110	DEN-000315-0006-0005	25.	40.	90.	.8	30.
111	DEN-000316-0006-0004	25.	50.	120.	1.2	35.
112	DEN-000317-0005-0004	25.	50.	100.	1.2	35.
113 A	DEN-000318-0004-0004	30.	45.	100.	2.4	25.
114 B	DEN-000319-0005-0005	20.	65.	100.	1.2	25.
115 A	DEN-000320-0004-0005	30.	130.	155.	1.6	35.
116 A	DEN-000321-0003-0005	25.	45.	95.	.4	35.
117 A	DEN-000322-0003-0006	30.	65.	120.	3.6	25.
118 B	DEN-000323-0003-0010	30.	20.	70.	1.2	10.
119 B	DEN-000324-0006-0012	70.	130.	220.	2.0	110.
120 B	DEN-000325-0006-0013	95.	150.	290.	2.2	150.
121 B	DEN-000326-0006-0014	300.	385.	1000.	6.2	750.
122	DEN-000327-0006-0015	90.	125.	340.	2.4	130.
123	DEN-000328-0006-0016	45.	90.	140.	1.6	85.
124	DEN-000329-0006-0017	50.	80.	210.	1.6	70.
125	DEN-000330-0006-0018	25.	65.	90.	1.2	35.
126	DEN-000331-0005-0018	60.	100.	190.	1.6	130.
127	DEN-000332-0005-0019	35.	55.	130.	1.2	45.
128	DEN-000333-0005-0017	70.	135.	170.	2.0	150.
129	DEN-000334-0005-0016	25.	55.	90.	1.6	40.
130	DEN-000335-0005-0014	295.	375.	610.	3.6	400.

JOB NO. MVU 997
February 24, 1986
PAGE 5

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb 1(ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
131 B	DEN-000336-0005-0012	45.	85.	160.	2.0	50.
132	DEN-000337-0005-0011	90.	135.	300.	2.0	120.
133	DEN-000338-0005-0010	30.	85.	130.	1.8	25.
134	DEN-000339-0004-0010	35.	75.	130.	1.6	35.
135	DEN-000340-0004-0011	55.	95.	270.	2.0	70.
136	DEN-000341-0003-0011	40.	45.	140.	1.6	25.
137	DEN-000342-0003-0012	45.	55.	120.	1.6	35.
138	DEN-000343-0002-0012	60.	70.	150.	2.0	35.
139	DEN-000344-0002-0011	25.	40.	100.	1.2	30.
140	DEN-000345-0002-0010	30.	50.	100.	1.6	25.
141	DEN-000346-0001-0011	15.	40.	50.	1.6	25.
142	DEN-000347-0000-0012	125.	85.	220.	2.0	60.
143	DEN-000348-0001-0012	110.	265.	330.	2.8	580.
144	DEN-000349-0001-0013	35.	40.	100.	1.6	30.
145 A	DEN-000350-0000-0014	25.	30.	80.	1.6	35.
146 A	DEN-000351-0000-0015	15.	25.	60.	1.2	25.
147 A	DEN-000352-0001-0015	20.	500.	300.	1.2	40.
148 A	DEN-000353-0001-0016	30.	65.	110.	1.2	35.
149 A	DEN-000354-0002-0016	25.	45.	95.	1.2	25.
150 A	DEN-000355-0003-0016	55.	75.	90.	1.2	50.
151 B	DEN-000356-0004-0016	210.	290.	750.	5.6	340.
152	DEN-000357-0004-0014	95.	150.	290.	2.4	140.
153	DEN-000358-0004-0015	80.	145.	230.	1.6	160.
154	DEN-000359-0003-0015	225.	390.	700.	4.4	370.
155	DEN-000360-0004-0017	195.	320.	640.	3.6	300.
156 A	DEN-000361-0004-0018	50.	65.	100.	1.6	70.
157 A	DEN-000362-0004-0019	20.	50.	70.	.8	25.
158 A	DEN-000363-0003-0018	20.	30.	60.	.8	40.
159 A	DEN-000364-0003-0017	20.	30.	70.	1.0	25.
160 B	DEN-000365-0002-0013	65.	110.	160.	1.6	70.
161 B	DEN-000366-0005-0008	30.	45.	120.	1.6	40.
162 B	DEN-000367-0005-0009	35.	50.	100.	1.2	35.
163 A	DEN-000368-0004-0009	30.	55.	120.	2.0	35.
164 A	DEN-000369-0004-0008	25.	35.	90.	1.6	40.
165 A	DEN-000370-0003-0008	50.	30.	110.	1.2	30.

ITEM	SAMPLE NUMBER	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Hg (ppb)
166 A	DEN-000371-0003-0009	40.	170.	155.	3.2	130.
167 A	DEN-000372-0004-0007	25.	70.	110.	2.0	40.
168 A	DEN-000373-0003-0007	25.	60.	120.	1.6	140.
169 A	DEN-000374-0004-0006	15.	30.	60.	1.2	35.
170 B	DEN-000375-0005-0006	15.	30.	80.	1.6	25.
171 B	DEN-000376-0006-0006	40.	45.	100.	2.0	35.
172 B	DEN-000377-0005-0007	20.	50.	90.	1.6	30.
173 A	DEN-000378-0002-0009	5.	50.	40.	.8	40.
174 B	DEN-000379-0004-0012	55.	50.	140.	1.6	50.
175 B	DEN-000380-0003-0013	100.	145.	290.	2.4	170.
176 B	DEN-000381-0004-0013	65.	100.	210.	2.0	130.
177 B	DEN-000382-0005-0013	35.	70.	120.	1.2	55.
178 B	DEN-000383-0003-0014	90.	120.	260.	2.4	180.
179 A	DEN-000384-0002-0018	15.	40.	60.	1.2	50.
180 A	DEN-000385-0001-0017	35.	140.	120.	1.6	80.
181 A	DEN-000386-0004-0020	20.	50.	80.	1.2	30.
182 A	DEN-000387-0005-0020	55.	90.	330.	3.2	80.
183 A	DEN-000388-0003-0019	20.	55.	75.	1.6	40.
184 A	DEN-000389-0002-0017	15.	25.	70.	1.2	20.
185 A	DEN-000390-0000-0018	20.	65.	60.	2.0	50.
186 A	DEN-000391-0002-0015	25.	60.	90.	2.0	40.
187 A	DEN-000392-0000-0016	20.	25.	60.	1.2	20.
188 A	DEN-000393-0000-0017	70.	50.	105.	1.6	30.
189 A	DEN-000394-0000-0020	20.	105.	80.	1.2	95.
190 B	DEN-000395-0005-0015	90.	205.	440.	2.8	100.
191 A	DEN-000396-0000-0019	25.	50.	115.	1.6	140.
192 A	DEN-000397-0001-0019	20.	75.	100.	2.0	65.
193 A	DEN-000398-0001-0020	15.	50.	70.	1.6	40.
194 A	DEN-000399-0002-0019	20.	30.	70.	1.2	35.
195 A	DEN-000400-0002-0020	15.	25.	60.	1.2	25.
196 A	DEN-000401-0003-0020	15.	40.	65.	1.6	30.
197 A	DEN-000402-0001-0018	20.	35.	90.	1.6	35.
198 B	DEN-000403-0006-0019	45.	75.	190.	2.0	55.



LEADVILLE.

Colorado

ITS

GOLD AND SILVER MINES,

FARMS AND STOCK RANGES,

AND

HEALTH AND PLEASURE RESORTS.

Tourist's Guide

TO THE

ROCKY MOUNTAINS.

BY FRANK FOSSETT.

New York:
C. G. Crawford, Printer and Stationer, 49 and 51 Park Place.
1879.

paid for sulphuret ores containing no lead are: for ores running less than one ounce in gold, six ounces in silver, and not under six per cent. copper, $10 per ton and upwards, adding $1 per ton for every additional per cent. of copper, the ore to be delivered on board cars at Black Hawk, viz.: ore running 66-100 of an ounce in gold, 5 ounces in silver and 7 per cent. copper, $10 per ton is paid; ore running same in gold and silver, and 10 per cent. copper, $18 per ton; ores running over one ounce in gold, six ounces in silver, and six per cent. copper, and not exceeding in value over $2 per ton, $20 an ounce in gold, silver at New York quotations, and $2 for every per cent. of copper, less ten per cent. and $20 for treatment, delivered on board cars.

The first smelting was done at Golden in 1872. After some suspension of work, the Golden Smelting Company became owners of and remodeled or enlarged the original concern. The value of gold, silver, and lead, produced in 1876, was reported at over $150,000, and at $275,000 in 1877. This was the product of ores purchased from Gilpin, Clear Creek, Boulder, and from what is now Custer county. A small amount came from Park, in the latter year. The process is smelting with lead.

Last year business was much better, and in the summer and fall the capacity was enlarged to eighteen tons daily. The product of the year 1878 was $384,122. From Gilpin county ores was obtained $60,865 worth of gold and $22,936.75 worth of silver. Clear Creek sent $204,403, nearly all silver; Boulder, $48,123 in gold and silver; Park, $14,498 in silver, with a small amount of lead, and the Leadville carbonates turned out $33,896. The latter have since been coming in large quantities. The total product of the works from first to last has exceeded one million.

The great buildings in the upper portion of Golden erected for, and for a time operated as, smelting works are now occupied by the Golden ore buying and sampling agency of Messrs. Netter, Matthews & Co. Ores are also bought and shipped from Denver. This firm has dealt largely in ores from all quarters, but especially in those of Clear Creek and Custer counties. The mill of Matthews, Morris & Co., in Georgetown, sampled, purchased and shipped more ore in 1878 than any other engaged in that line of business with possibly one exception. The mill at Golden is supplied with all machinery and appliances for the conduct of a large business.

The smelting works at Argo are the successors of the Boston and Colorado Company's long established operations in the mountains. Professor N. P. Hill was the founder and has ever been the managing director of that company's smelting establishments. He began work at Black Hawk, in January, 1868, with one calciner and one smelting furnace. All around him were wrecks of preceding attempts at ore reduction, but, while encountering many difficulties in the earlier years, there has never been an interruption of work, general progress or success.

First Argo smelter in Blackhawk

As the ore-supplying mining districts became more numerous and extensive, the furnaces and working forces were increased, and in time a corps of assistants had been secured such as is seldom met with, and whom it would almost be an impossibility to replace. The rare business and executive qualifications of the general manager have been ably seconded by those whom he has called to responsible positions, while the State has shown its appreciation of services rendered its main industry by awarding him a seat in the United States Senate.

This copper matte method of smelting, old and tried in other lands, has required many adaptations to the numerous and varied ores it has had to deal with, and as now conducted at this establishment can be termed the Colorado more appropriately than the Swansea process. When Professor Richard Pearce took charge of the metallurgical department, away back in 1873, the production of the first absolutely pure silver bullion in the West began. Before that the valuable metals had been sent from Black Hawk across the ocean to Swansea, in the form of copper matte, where they were purchased, separated, and refined. Since 1875 the gold has also been parted and refined in Colorado, and by a method of Mr. Pearce's own invention.

refining method

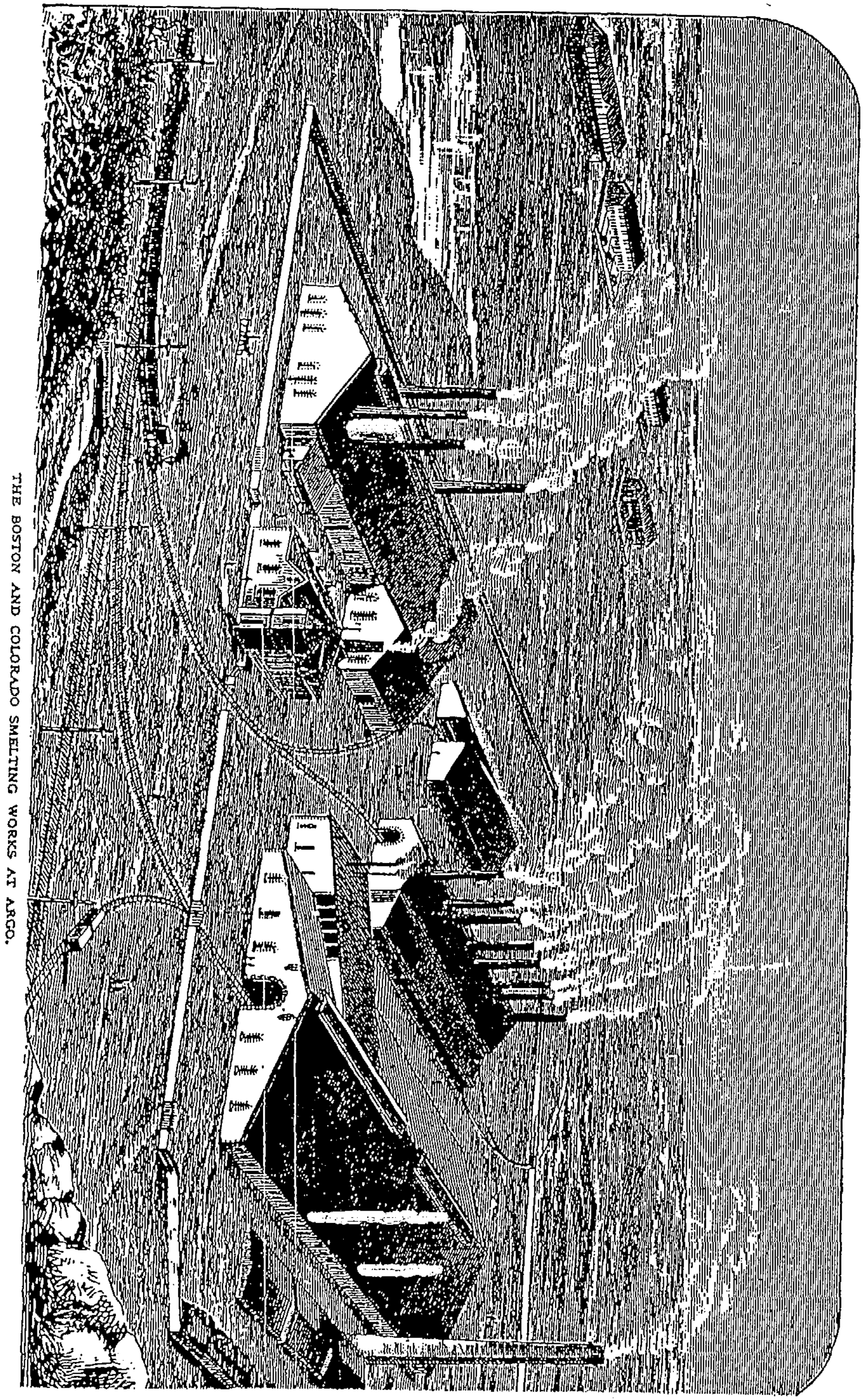
In 1873 branch works were started at Alma, among the Park county silver mines, and in 1876 an ore buying agency was established at Boulder. In 1877-8 the capacity of the Black Hawk works was over fifty tons of ore daily, instead of ten or twelve, as at the beginning. The working force had increased to a hundred men, the annual production of bullion from a coin value of $193,490 in 1868 to one of over two millions, and the average stock of ores on hand represented a value of three quarters of a million. Ores were coming in steadily from almost all parts of the State, and began to arrive from Montana, even, a thousand miles away. But the question of fuel was becoming a serious one, a more central and generally accessible locality was desirable, and as it was necessary to again enlarge the works it was deemed best to build entirely anew, and near the coal measures and the railway centre of the plains.

* Denver smelter

A location was selected two miles from Denver, to which the very appropriate name of Argo was applied, after the good ship in which a hero of Grecian mythology is reputed to have set sail in search of the golden fleece. The new works were so far completed in December, 1878, that several furnaces were fired up, and soon after all business, except roasting ores on hand, and sampling, purchasing and shipping, was discontinued at the old place at Black Hawk.

The works at Argo were constructed after the most approved plans which long experience and the necessities and advantages of the situation could suggest. The result is the finest and most extensive gold and silver reducing establishment in the world. This will be enlarged hereafter, but already possesses a nominal capacity for treating 120 tons of ore, or a practical capacity of 100 tons daily from one year's end to another, with the following enormous plant: 30 great kilns for roasting and desulphurizing the ore, and requiring wood for fuel; 10 ore calciners or roasting furnaces; 8 ore smelting furnaces; 8 calcining furnaces in the refining department; and five melting furnaces; together with engines and other necessary machinery. Two hundred men are employed, more than a quarter of a million in bullion is turned out monthly, and one hundred tons of Cañon and El Moro coal are consumed daily, beside a small quantity of wood. The stock of ores carried on hand exceeds $1,000,000 in value. Ore and coal trains pass over side tracks from the adjacent Colorado Central railway into the yard and receptacles prepared for them.

In the great ore building, 450 feet long by 120 wide, are scales for weighing loaded and empty cars, steam engines for propelling the ore-crushing and sampling machinery, and ten calciners—each roasting 9,600 pounds of ore every twenty-four hours. Adjoining are thirty roasting kilns, and a smoke-stack 100 feet high, that carries off the sulphurous fumes of both calciners and kilns. The products of all the different furnace buildings are conveyed from one to another in cars over connecting railways.



THE BOSTON AND COLORADO SMELTING WORKS AT ARGO.

In another building nearly 800 feet long and directly opposite are eight furnaces that smelt 100 tons of roasted ores into five of matte every twenty-four hours, while the refuse remains in what is called slag. After the slag has been skimmed off of the matte, the latter is transferred to another massive building, pulverized by crushers and rollers and roasted in the calciners of the refining department—eight in number. A line of vats is the next receptacle, into which continuous streams of hot water are conveyed by pipes. This hot water holds the silver in solution, and in a series of tanks below, the silver is precipitated or retained on lines of standing copper plates from which it is removed every week. The bright, pure flaky metal is secured in immense crucibles, and is shoveled into buckets and conveyed to the melting furnaces, five in number. There it is melted into solid bars of an average weight of about 1,700 ounces, valued at $1,900 more or less. The copper and gold are saved separately from the silver, the copper being secured on scrap iron. The gold bricks vary in value from $15,000 to $27,000 each. Centrally located is the handsome structure used as the headquarters and offices of managers Hill and Wolcott.

A TON OF PURE SILVER.

All of the buildings are of cut stone, covered with roofs of corrugated iron, and outside of the works are buildings for the employees and their families. This village has three hundred people, with a school and church,

The production of the works for four years in the various metals, and by counties, was as follows:

Counties.	Gold.	Silver.	Copper.	Total.
1875.				
Gilpin	$357,000	$94,000	$51,000	$502,000
Clear Creek	4,000	438,000	......	442,000
Park	41,000	618,000	19,000	678,000
Boulder	113,900	74,000	......	187,000
Fremont	......	126,000	.....	120,000
Gold and Silver, San Juan and elsewhere	......	......	.....	12,000
Totals	$515,000	$1,350,000	$70,000	$1,947,000
1876.				
Gilpin	$594,000	$132,000	$78,000	$804,500
Clear Creek	5,400	529,000	......	534,400
Park	39,000	458,000	14,000	511,000
Boulder	86,000	49,000	......	135,000
Fremont	......	102,000	......	102,000
Other Sources	......	......	......	11,000
Totals	$724,400	$1,270,000	$92,500	$2,097,000
1877.				
Gilpin	$591,500	$137,500	$86,000	$815,000
Clear Creek	6,500	707,000	3,000	716,500
Park	38,000	221,500	8,000	268,000
Boulder	169,000	90,500	......	259,500
Custer	14,500	76,500	.. ..	91,000
Other Sources	.....	......	... ..	4,000
Totals	$819,500	$1,233,000	$97,500	$2,154,000
1878.				
Gilpin	$608,500	$181,000	$79,000	$868,500
Clear Creek	4,500	559,500	2,000	566,000
Boulder	178,000	73,000	......	251,000
Park	16,500	114,000	4,000	134,500
Custer	83,000	52,500	......	135,500
Montana Territory	.....	254 000	36,000	290,000
Other Sources	3,500	10,000	......	13,500
Totals	$894,000	$1,244,000	$121,000	$2,259,000

The currency value of the company's bullion product previous to 1879 was as follows:

1868	$270,886	1875	$1,947,000
1869	489,875	1876	2,097,000
1870	652,329	1877	2,154,000
1871	848,571	1878	2,259,000
1872	999,954		
1873	1,210,670	Total	$14,568,162
1874	1,638,877		

This company now does its smelting entirely at Argo. It has ore-buying agencies with sampling mills at Boulder, Black Hawk, and Alma, and receives ore from nearly every mining district in Colorado. Now that the capacity is about double what it was at Black Hawk, it is likely that the bullion product will show a proportionate increase.

CHAPTER IV.

COLORADO'S MINING PRODUCT FROM THE EARLY DAYS TO THE PRESENT TIME—A MASS OF STATISTICS—THE YIELD OF GOLD, SILVER, LEAD, AND COPPER—EIGHTY MILLIONS, AND TWENTY MORE COMING IN SEVENTY-NINE—TONS OF GOLD AND SILVER.

No definite record was kept of Colorado's mining product prior to 1868, and the estimates of miners and bullion shippers alone remain to base a statement of the yield of the earlier years on. Neither the mints nor express companies handled anywhere near all of the gold produced in those days. A published statement of Colorado's output has appeared in print once or twice in recent times, but it is wide of the mark. The amounts given for the early placer mining times are too small, and those for the nine years up to 1872 are too large.

The excess from 1863 to 1869 was evidently as much as six millions, and for the three years succeeding the latter date at least three millions. The figures given for the latter period were like those furnished by Colorado men to Professor R. W. Raymond for his annual reports. The yields for both periods were originally computed on a currency basis, when gold ranged from $1.30 to $2.50, and after the lapse of years were rated as coin values. The express agents of Wells, Fargo & Co. always furnished their figures on a currency basis, and so did all Colorado bankers, smelters, mill men and miners, unless the words "coin value" were given. The figures in this book represent coin values unless otherwise stated.

The placers and gulches of Lake, Summit, Park, and Gilpin counties yielded largely for several summers, beginning with that of 1860, and when they were on the decline, the lode mines, mainly in Gilpin county, came to the front. These were doing well in 1862, and still better in 1863-4. Lodes and placers gave a varying yield, however, from 1860 to 1865. Besides the above named counties, both classes of mining were prosecuted in Clear Creek and Boulder. The product of the territory dropped to low figures in 1866, and there was no heavy increase from that time until the

THE ARGO WORKS

OF THE BOSTON AND COLORADO

SMELTING COMPANY

BY

DONALD T. KLODT

Senior in Metallurgical Engineering

Colorado School of Mines

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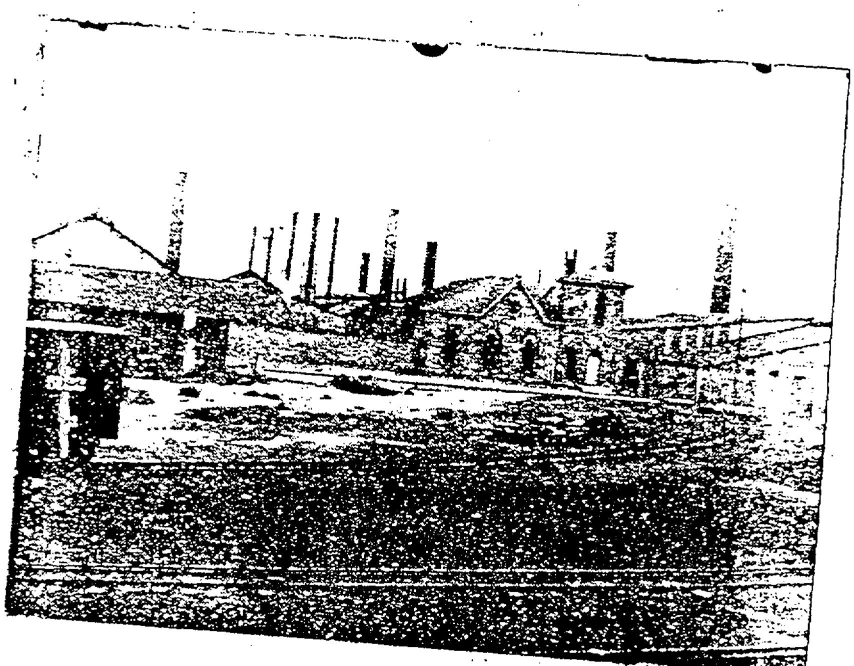

THE ARGO SMELTER IN 1900
(Courtesy of the Colorado State Historical Society)

THE ARGO SMELTER

The story of the Argo Works of the Boston and Colorado Smelting Company is centered around the efforts and activities of two men: Dr. Richard Pearce, a graduate of the Mining School of Truro, Cornwall, and the Royal School of Mines, London, and Professor Nathanial P. Hill, a graduate of Brown University.

Professor Hill was instrumental in the building of Boston and Colorado's first smelter at Black Hawk, Colorado and was manager of the Black Hawk works and later manager of the Argo works. Dr. Pearce was engaged by the company in about the year 1873 for the supervision of the building of the separation works at Black Hawk. Professor Hill and Dr. Pearce planned to use the "Swansea" method of smelting at these new works. This smelting method, which dealt with the recovery of gold and silver by means of a copper matte, had never before been used in this country.

The works at Black Hawk, which were called "Colorados first successful smelter," used wood for the fuel of all of its smelting operations. The furnaces were necessarily small, and so in 1877, the scarcity of wood and increased business prompted the management to select a coal to replace the wood as the fuel. After testing the coals of the region, the coking coals of Trinidad were found to possess the desired properties.

The cost of transporting the coal to Black Hawk, however, was so great that it was soon realized that the works would have to be moved to a location nearer the source of the fuel. Denver, because of its proximity to the coal fields as well as the mining districts, was the logical choice for the site of the new plant.

The ground chosen for the site of the new works was about two miles north of Denver and one-quarter mile west of the Platte River. Construction was begun June 29, 1878, and by the fifteenth of December, the furnaces were handling fifty tons of ore per day. The building force was about one hundred men, who either lived at the temporary boarding houses set up on the grounds, or returned each day to Denver. Transportation for the labor force to and from the construction was a dummy engine and a passenger coach which had been loaned to the company by the railroad.

The buildings were all of brick and stone, 2,500,000 brick and 5000 perches of rock being required for the construction. Ten to twelve carloads of rock from Morrison, Colorado were delivered daily to the building site. The buildings were roofed with corrugated iron. In all, there were four main buildings on the grounds: namely, the calcining house, the smelting house, the refining house, and the office building. These buildings and the adjoining grounds were surrounded by an eight-foot high stone wall, the enclosed area being about twelve acres. Outside the area, and away from the plant, a hotel and several cottages were constructed for the smelter's employees. The speed with which the plant was constructed and the operations started might be very hard to duplicate today, what with material shortages, strikes and other delays.

In 1879, the smelter had thirty kilns, ten roasters, eight smelting furnaces, eight calcining furnaces, and five melting furnaces. The size and capacities of the furnaces were changed in later years as the need presented itself and as improvements were made. One of the more notable improvements was the introduction of the Pearce roaster, invented and patented by Dr. Pearce while he was at the Argo works. Dr. Pearce also obtained several other patents on methods and equipment developed at the smelter.

The ore smelting practice at Argo was essentially the same as that used at the old Black Hawk works. However, one improvement in the smelting practice was the heat savings gained by taking the calcines from the roasters and charging them, while still red hot, directly to the smelting furnaces. Another development was that of smelting ores to a copper matte and slag in reverberatory furnaces. In 1900, the Argo smelter was the only one in the United States that smelted gold and silver ores to matte exclusively in reverberatories.

Capacity of the plant was increased from fifty tons of ore per day to a maximum of one hundred and twenty or an average of one hundred tons per day. The capacity of the reverberatories increased from five to one hundred tons.

The ores bought by the smelter were of a general assay of about 40 to 60 oz silver per ton, 1/2 to 1 oz gold per ton, and 2 or 3 per cent copper. About 90 per cent of the ore contained little or no copper, and so the copper assay given above resulted from the mixing with the remaining 10 per cent which was high in copper.

About one hundred tons of high-sulphur ore was roasted each day in order to reduce the sulphur to around 7 per cent. The remainder of the daily tonnage could be smelted directly without any preliminary roasting operation. The roasted ore was mixed with the unroasted ores, which were principally of a siliceous nature. This ore mixture was then smelted to produce a slag and a first matte. This first matte generally assayed 40 per cent copper, 400 oz silver per ton, and 6 oz gold per ton, which represents a concentration of about 13 to 1.

The next step in the smelting operation was to roast part of the first matteand then mix this roasted matte with the unroasted portion, the mixture then smelted. The products of this operation were a rich slag and a matte called the "white metal". The slag was skimmed from the white metal and returned to the ore furnace. The white metal, containing 700 to 800 oz of silver per ton, 10 oz of gold per ton, and 60 per cent copper was then ready for the extraction of the silver.

The white metal was roasted for twenty-four hours to drive off the largest part of the sulphur. The roasted metal was then ground to minus 60-mesh and given a sulphatizing roast to obtain the sulphate of silver. The material was then ready for leaching. The material was leached in wooden tubs with hot water as a solvent. The silver sulphate was dissolved easily and the water, when saturated with the silver sulphate, was passed over copper plates to precipitate the silver. The copper which replaced the silver in the solution was recovered by passing the solution over scrap iron.

The precipitated silver required some additional refining because of copper oxide and metallic copper mixed in with it. The precipitated silver was therefore treated with boiling dilute sulphuric acid, which removed the copper as the sulphate. The silver was then washed, dried, and melted and cast into bars of approximately 999 fineness.

The residues from the leach step were mixed with gold- or silver-bearing pyrites, rich in sulphur, and were again smelted to a matte. This matte contained about 10 to 15 oz gold per ton and 80 oz per ton silver. The slag from this step was of a low grade and was discarded.

This last matte was charged to a reverberatory where it was melted down in two stages, the first stage being an oxidizing one. During the second stage of melting no further oxidation occurred, but a reaction took place between the oxide and the sulphide. This reaction produced metallic copper which contained most of the gold and silver. The charge was tapped into sand moldswhere a separation of the matte and copper-gold alloy occurred. The slag from the process was returned to the ore furnace; the matte was treated in the same manner as the rich silver matte described above, but in separate furnaces as it contained no gold.

The treatment and refining of the rich copper-gold alloy was a very carefully guarded metallurgical secret for thirty-five years. The process was developed by Dr. Pearce in 1873 while he and Professor Hill were working on the Black Hawk works, and is known as the Pearce process. It was not until 1908, two years after a fire completely destroyed the refinery building at the Argo works, that the management agreed to disclose the secret process. The process, which is described in the following paragraphs, was so simple.that this was given as the reason why no one discovered it during the many years of its use.

The gold-copper alloy, or copper bottoms, was granulated and melted down with pyrite to form a matte and a copper-gold alloy richer in gold than the one charged. The reason that the second copper bottoms were richer is obviously that some of the copper goes into the formation of the matte, leaving the gold behind. The second copper bottoms were granulated and melted with pyrite, as were the first bottoms. This process was repeated several times until all the copper was extracted from the alloy. The gold was then melted and cast into bars for sale to the United States mint.

All the slags from each process were routed back until eventually they reached the ore-smelting furnaces. For a good many years the slag from the ore furnace was picked over by hand to sort any prills of metal or any obviously rich pieces. This practice of hand sorting did not reclaim much of the value contained in the slag, and so in later years an improved slag treatment was instituted at the smelter. Small auxiliary furnaces were built for each of the ore furnaces, and the slag from the ore furnaces was skimmed directly into these smaller reverberatories. To the slag in the auxiliary furnaces was added clean pyrite and the mixture was then allowed to remain undisturbed at a high temperature for a short time. The pyrites combined with the metal in the slag and formed a small quantity of low-grade matte which collected beneath the slag. This matte contained all the values and left the slag very clean. The slag was then tapped and discarded as clean slag.

Ores recieved at the plant were in the main part from the following Colorado counties: Gilpin, Clear Creek, Boulder, Park, and Custer. The remainder of the ore was from Montana Territory, New Mexico Territory, and other localities. Coal was from the mines of Southern Colorado, 250 to 275 tons used each month.

Many millions of dollars worth of metal were refined by the smelter during its operation, the first year producing $894,000 of gold, $1,244,000 of silver, and $121,000 of copper or a total of $2,259,000.

It might be of interest to note one reason why copper was selected as a vehicle for the gold and silver instead of lead. First, the great Leadville discoveries were not made until 1877, four years after the smelter at Black Hawk was started; and second, in 1871, one Clear Creek smelter imported pig lead from Chicago at a cost of $130 per ton for freight alone! It was obvious, then, that the smelter at Black Hawk could not possibly be operated profitably using lead as a collector. The copper-matte process developed at Black Hawk was so successful that it was continued at Argo, even after the Leadville discoveries.

As mentioned previously, the refinery was destroyed by fire in 1906, and no further refining was done at the smelter. From 1906 on, the copper ores became scarce in this region and copper smelters in Utah, Arizona, and New Mexico further shortened the supply. The management of the Argo works decided not to convert to a lead smelter, and so it was voted to shut down the smelter completely. It was for the above mentioned reason alone and not because of competition that the famous smelter was shut down forever on March 17, 1910, exactly forty-two years ago this month.

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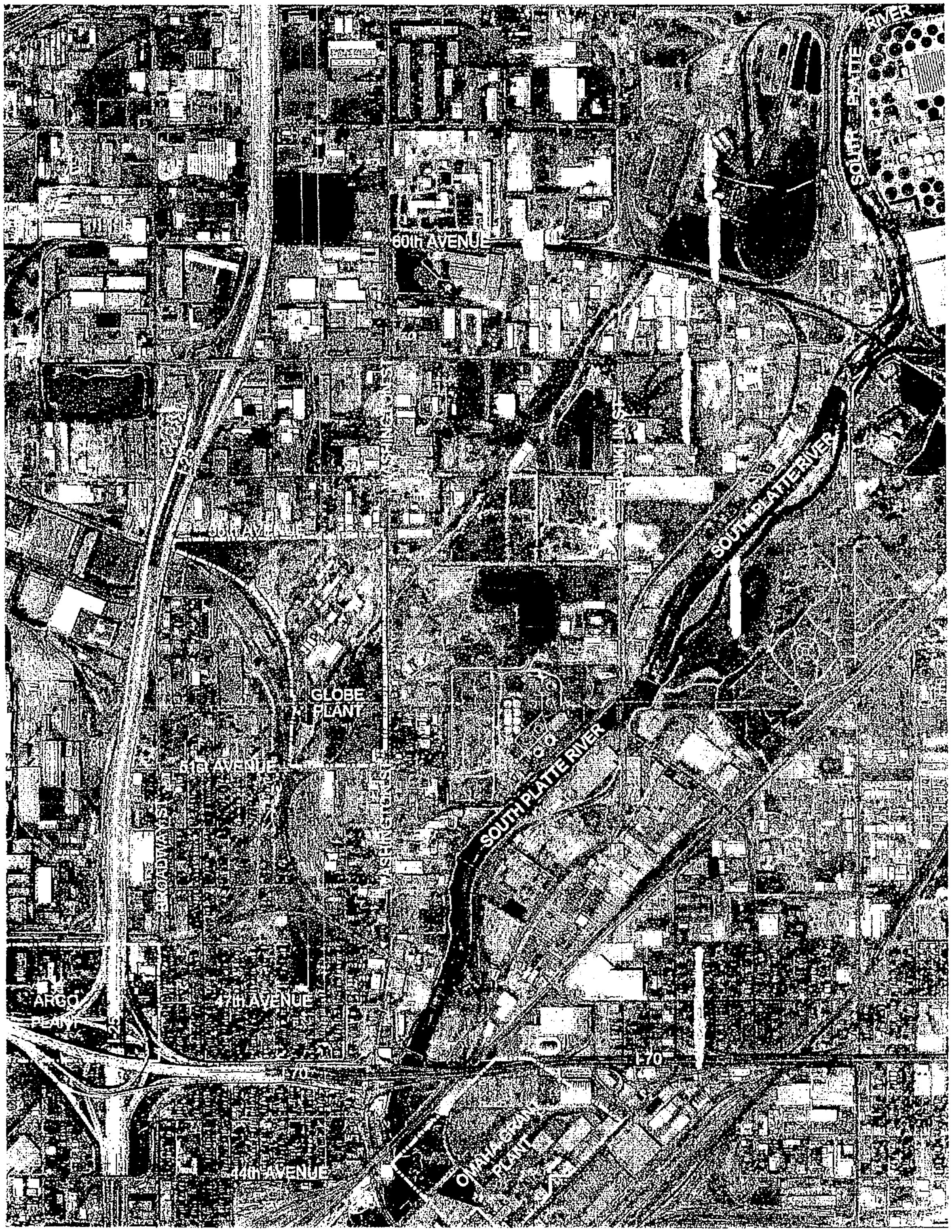

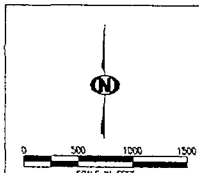

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